HELIOS I

COMPUTER FRONT END

Service Manual

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INTRODUCTION

WARNING

SERVICING DESCRIBED IN THIS MANUAL IS TO BE
PERFORMED BY QUALIFIED PERSONNEL ONLY. TO AVOID
ELECTRIC SHOCK OR DAMAGE TO THE INSTRUMENT,
PERFORM ONLY THE SERVICING EXPLICITLY DESCRIBED
IN THIS MANUAL.

The Helios I Service Manual is a service and maintenance guide
(including replacement parts lists) to the Computer Front End. The
Service Manual complements the Helios I System Manual, which provides
installation, operating, and system configuration information.

The Service Manual covers standard mainframe and option assemblies, and
provides general maintenance, cleaning, performance testing,
calibration, and board-level troubleshooting procedures. The Helios I
Service Manual is to be used by technicians and maintenance personnel
who need detailed, technical information about the electronics of the
Front End.

Information needed to maintain the Front End and to isolate problems to
circuit board level is given in this manual. Theories of operation and
schematics for the mainframe and options are provided to aid those
qualified to troubleshoot beyond the circuit board level.

When the defective assembly has been identified, returning the Front End
to service can frequently be expedited by using our Module Exchange
Program (MEP). Because MEP cannot be performed in some countries, we
recommend that you contact your local Fluke authorized Service Facility
(listed in Appendix C) to obtain instructions for replacement or repair.

ORGANIZATION

Section 1   How to Use This Manual

                 Describes the organization and use of the Service Manual.

Section 2   General Information

                 Describes the Front End and its available accessories and
                 options. Required test equipment, shipping, and factory
                 service information are included here.

Section 3   Theory of Operation

                 Covers the theory of operation for the Front End
                 mainframe. Option assembly theory is contained in the
                 individual option subsections of Sections 8 and 9.

Section 4   Maintenance

General maintenance of the instrument, cleaning
instructions and procedures to gain access to and remove
mainframe assemblies are included here.

Section 5   Testing and Troubleshooting

Consists of mainframe performance tests and
troubleshooting procedures designed to isolate a
malfunction to the circuit board level. Component level
troubleshooting may be performed using the Theory of
Operation (Section 3) and Schematic Diagrams (Section 7).

Section 6   List of Replaceable Parts

Contains parts lists for the Front End mainframe and
gives parts ordering information. Option assembly parts
lists are in the individual subsections of Sections 8 and
9.

Section 7   Schematic Diagrams

Presents Front End mainframe schematics on foldout pages.
Schematics for option assemblies are located in the
individual option subsections.

Section 8   Options -160 Through -169

Covers Options -160 through -169 in subsections ordered
numerically by option number. Includes theory of
operation, performance test procedures, calibration
instructions (where applicable), schematics, and a
replacement parts list.

Section 9   Options -170 Through -179

Covers Options -170 through -179 in subsections ordered
numerically by option number. Includes theory of
operation, performance test procedures, calibration
instructions (where applicable), schematics, and a
replacement parts list.

Section 9A   Scan/Alarm Option -201

Includes description, theory of operation, performance
test procedure, parts list, and schematic diagram.

Section 10   Appendices

A   Specifications
B   Federal Supply Codes for Manufacturers
C   Service Centers
D   Manual Status Information

HOW TO USE THE MANUAL SET

The Helios I Computer Front End is supported by a manual set consisting of two manuals.

System Manual

The Helios I Computer Front End System Manual describes all aspects of Helios I installation and operation.

The System Manual provides all the information necessary to define required functions, identify system requirements, make the necessary hardware connections, and verify correct operation. An inexperienced user may need all this information to install the Front End and make it operational. A user who is already familiar with the instrument may only need to refer to this information occasionally. In either case, each element of the installation process is easily accessible and fully referenced.

Service Manual

The Helios I Computer Front End Service Manual is the maintenance guide to the Front End.

The Service Manual contains general maintenance, cleaning, performance testing, calibration, and board-level troubleshooting procedures. The Service Manual also includes theory of operation, parts lists, and schematic diagrams for mainframe and option assemblies.

CONVENTIONS

o   Reference to the Instrument

The Helios I Computer Front End will generally be referred to as the "Front End". The terms "Helios I" or "Computer Front End" will also be used. Where a Helios I or Computer Front End equipped with a Scan/Alarm (-201) option is concerned, the term "(Scan/Alarm)" is attached to the instrument name.

o   Printed Circuit Assembly

A printed circuit assembly (pca) is a printed circuit board with components mounted on it.

o   Logic Polarity of Signals

Logic signals whose names are followed by "(L)" are asserted or active low. On the schematic the same signal can be represented as "SIGNAL(L)" or SIGNAL overscored by a vinculum.

When a signal is followed by "(H)" or has no parenthetical postscript, it is active or asserted high.

o   Address Notations

Hexadecimal representation of memory addresses takes the form

        0x0000

Memory addresses ranges, where specified, are inclusive.

For example, address range

        0x0000 to 0x2000

includes addresses "0000" and "2000".

o   Keystroke Notations

The following conventions are used to identify syntax keystrokes and differentiate them from surrounding text:

(xxx)   When associated with a keyword, a lower-case word in parentheses indicates an input required by the user.

          For example, the command

              DEF CHAN(channel[s]) = DCIN <CR>

          means that the user must specify "channel[s]" to be defined as direct current input channel[s] to have a valid command.

XXX   Indicates a literal keyword to be entered by the user.

          For example,

              TIME

          means that you enter the literal word "TIME" or "time".

          The Front End is case insensitive and will accept any combination of upper- or lower-case letters. However, all Front End keywords in this manual which are not part of actual computer programs will appear in upper-case letters to distinguish them from surrounding text.

<XXX>   Angle brackets around all upper-case letters means press the <XXX> key.

          For example,

              <CR>

          means press CARRIAGE RETURN, RETURN, or ENTER (according to your keyboard.

..   "Double Periods" designate an inclusive range.

For example,

    CHAN(0..99) = 1 <CR>

assigns logic "1" to channels 0 through 99.

CONTENTS

DESCRIPTION

The Fluke Helios I Computer Front End is a highly accurate, easy-to-use data acquisition and control subsystem that can be used with any kind of personal or mainframe computer.

The Computer Front End is a medium speed, smart intermediary between a computer and a real world measurement application. With capacity ranging from a single channel in a minimal configuration to 1500 channels in a fully expanded system (1000 channels if the Scan/Alarm option is installed), the Front End can be adapted to a wide array of applications.

The Front End gathers data and generates control or stimulus signals through a standard computer interface. It combines a full range of measurement capabilities and is easy to program. The Front End's chassis includes:

o   An RS-232-C and an RS-422 standard serial interface port for communication with a host computer. (Serial printer port available with Scan/Alarm option.)

o   A microcomputer with ROM and RAM to provide local intelligence.

o   Six option slots that accept any of a range of measurement and control modules. This family of options supports a variety of both analog and digital inputs and outputs.

     Expansion chassis can be added to accommodate more input/output channels, up to a maximum of 1500 (standard system) or 1000 (Scan/Alarm option system).

Power Requirements

The Front End operates on either of two ac line voltage ranges: 90 to 132V ac, or 180 to 264V ac. Line frequency for either range may be from 47 through 440 Hz. If you need to verify or change either setting, refer to Section 4 for details.

CAUTION

Incorrect voltage selection may damage the
Computer Interface Module and void your warranty.
If the voltage is not set for the correct
operating voltage, the unit will either fail to
operate, or will be severely damaged.

External Features and Connectors

The features and connectors located on the front and rear panels of the Front End are shown in Figure 2-1 and described Table 2-1. Six horizontal slots are available for installing scanners, A/D Converters, and other measurement and control options.

FRONT PANEL

REAR PANEL

Note: Refer to Section 9A for additional features provided with the
Scan/Alarm option.
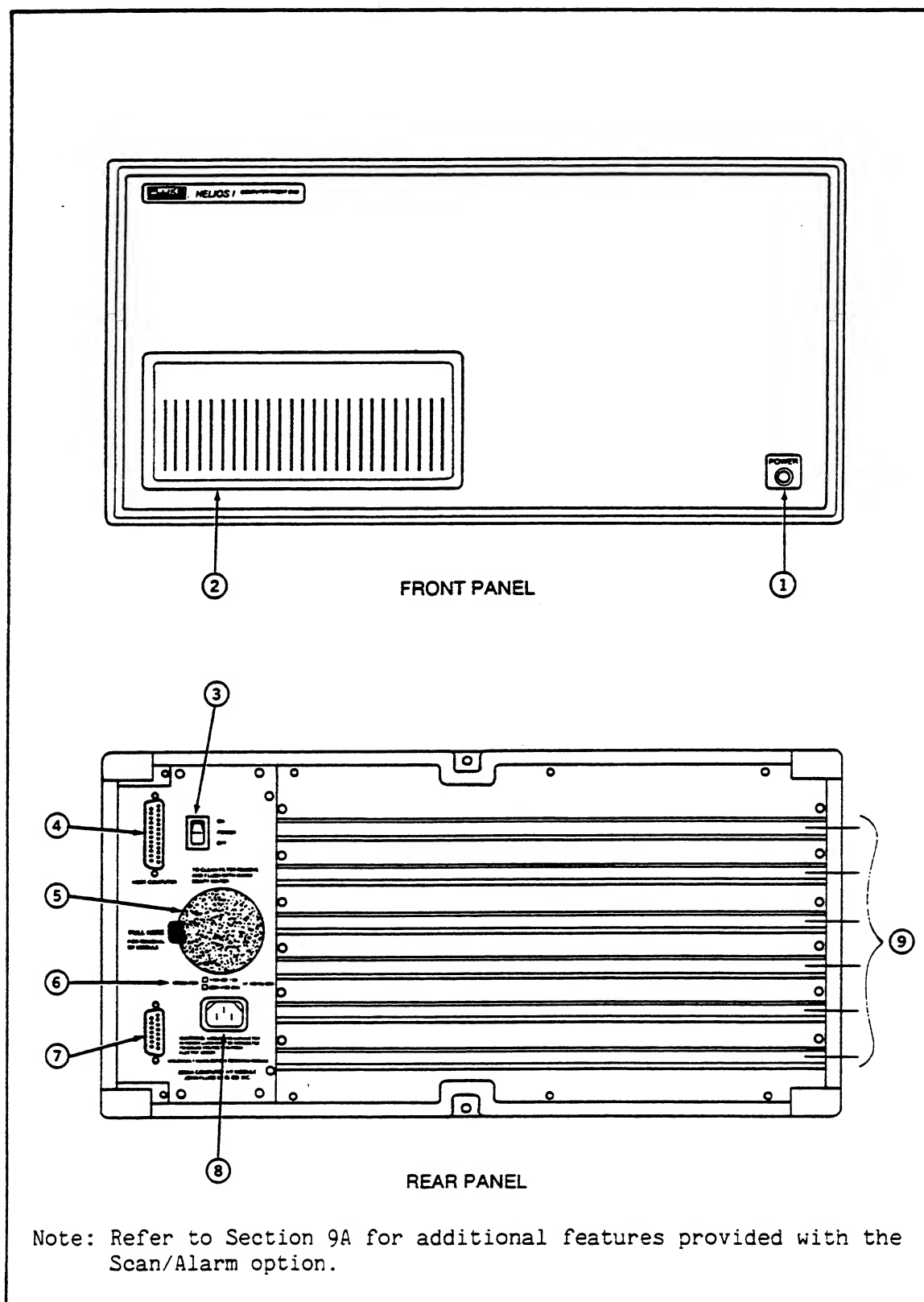
Figure 2-1. Front and Rear Panels

Table 2-1. Front and Rear Panel Features

ITEM	FEATURE	DESCRIPTION
1	Power Indicator	Green LED. Lit when Power is ON
2	Grill	Ventilation Grill
3	Switch	ON/OFF Switch for ac Line Power
4	25-Pin Connector	RS-232-C/RS-422 Connector to Host
5	Filter	Washable, Removable Fan Filter
6	Voltage/Frequency	Silk Screened Annotation of Line Voltage Selection and Frequency
7	15-Pin Connector	Connector to 2281 Extension Chassis
8	AC Input	Standard Three-Prong Socket
9	Slots	Six Slots for Front End Options

Note: Refer to Section 9A for additional features provided with the Scan/Alarm option.

The Front End's external dimensions are shown in Figure 2-2.

Figure 2-2. External Dimensions
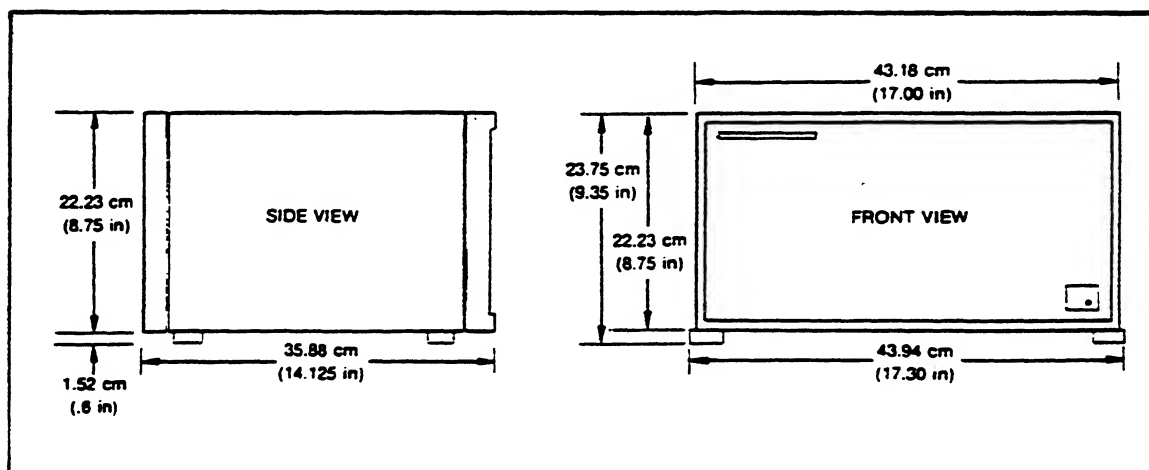
REQUIRED TEST EQUIPMENT

Equipment required for all Front End performance tests and calibration procedures is listed in Table 2-2. Equipment required for each test is also listed with the procedure in the applicable section or subsection.

Table 2-2. Summary of Required Test Equipment

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	+31.3 mV +/- 20 uV +2.048V +/- 50 uV -2.048V +/- 2 uV of +2.048 500 mV +/- 20 uV 6.2V +/- 155 uV 6.8V +/- 0.1V 5.0V +/- 100 uV 7.9V +/- 200 uV 63V +/- 800 uV 1.008V +/- 40 uV	Fluke Model 343
Digital Multi-meter DMM	Capable of measuring +12V dc	Fluke 77 or equivalent
Power Supply	Capable of sourcing +12V dc	Appropriate lab type
100:1 Divider	+/- 0.005%	Fluke Accessory Y2022
DC Voltmeter	+10V +/- 0.06V 50.0 mV +/- 0.001 mV 500.0 mV +/- 0.005 mV	Fluke Model 8502A
Resistance Calibrator	NA	Fluke 8505A
Resistor (4 each)	100 ohm 0.01% 5ppm/$^{\circ}$C	Fluke Part No. 491720
Resistor (2 each)	100 ohm 0.1%	Fluke Part No. 357400

Table 2-2. Summary of Required Test Equipment (cont)

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
Resistor	499 ohms 1% MF	Fluke Part No. 289256
Resistor, 2 each	220 ohms, 1W	Fluke Part No. 109462
Resistor	1 kilohm +/- 5%, 1/2W	Fluke Part No. 108597
Resistor	10 kilohm +/- 5%, 1/2W	Fluke Part No. 109165
Resistor	8 ohm +/- 0.25%, 1/2W	Fluke Part No. 641449
Oil or Water Bath	NA	
Mercury Thermometer	0.02 $^{\circ}$C resolution	Princo ASTM-56C
Calibration Extender/Fixture	NA	Fluke Accessory Fluke Part No. 648741 (no substitute)
Digital Extender Assembly	NA	2400A-4021 Fluke Part No. 486910
Toggle Switch	Single-pole, double-throw	Fluke Part No. 493825

OPTIONS, ACCESSORIES, AND OTHER RELATED EQUIPMENT

All options available for the Front End at the time of this printing are listed in Table 2-3. Refer to Sections 8 and 9 of this manual for further information on options.

All accessories are listed in Table 2-4.

Table 2-5 lists other related equipment for use with the Front End.

Table 2-3. Options

NUMBER	NAME	FUNCTION
-160	AC Voltage Input Connector	AC to dc conversion, voltage division, screw-terminal connections (for use with -162).
-161	High Performance A/D A/D Converter	Analog-to-digital converter, dual slope integration.
-162	Thermocouple/DC Volts Scanner	Scans 20 channels, 1 microvolt, 3 poles/channel (for use with Options -160, -161, -171, -175, or -176).
-163	RTD/Resistance Scanner	Scans 20 channels, 4 poles per channel, 1 pole/decade, precision current source excitation (for use with Options -161, -177).
-164	Transducer Excitation Module	Contains one precision 2V or 4V source and five precision 1 mA current sources (for use with Options -162, -174, -175, -176 and 10 dc channels of -160).
-167	Counter/Totalizer	Measures frequency or counts events on six channels.
-168	Digital I/O Assembly	Provides 20 single-bit channels for alarm or status input or output or for BCD or binary input (for use with -169 or -179).
-169	Status Output Connector	Provides 20 screw-terminal connections for external digital devices (for use with -168).

NUMBER	NAME	FUNCTION
-170	Analog Output Assembly	Four-channel current (4 to 20 mA) or voltage (0V to 10V or -5V to +5V) outputs, 12 bits.
-171	Current Input Connector	Provides 20 current input connections each with a shunt resistor (for use with -162).
-174	Transducer Excitation Connector	Provides screw-terminal connections for voltage and current sources (for use with -164).
-175	Isothermal Input Connector	Provides screw-terminal connections for 20 thermocouple input channels (for use with -162).
-176	Voltage Input Connector	Provides screw-terminal connections for 20 voltage input scanner channels (for use with -162).
-177	RTD/Resistance Input Connector	Provides screw-terminal connections for 20 channels of 3- or 4-wire RTD or resistance measurement (for use with -163).
-179	Digital/Status Input Connector	Provides screw-terminal connections for binary or status digital input signals (for use with -168).
-201	Scan/Alarm	Provides automatic channel scanning with local printout and alarm annunciation. Replaces standard Computer Interface Module.

Table 2-3. Options (cont)

Table 2-4. Accessories

ACCESSORY	DESCRIPTION
Y2044 Rack Slide Kit	Slide kit for mounting the Front End or the 2281A Extender Chassis in a 19-inch-wide, 24-inch-deep equipment rack.
Y2045 Rack Mount Kit	Mounting flanges for installing the Front End or the 2281A Extender Chassis in a 19-inch-wide, 24-inch-deep equipment rack.
Y2047 Extender Chassis Multi-Connector	Interconnection unit for connecting multiple 2281A Extender Chassis to the Front End.
Y2055 Serial Link Multi-Connector	Three-way connector assembly used in a multipoint serial link network
Digital Extender PCA Fluke Part No. 486910	Allows the Computer Interface Module to be extended out from the mainframe for troubleshooting.
Calibration Extender/ Fixture Fluke part No. 648741	Allows the horizontal pcas to be extended out from the mainframe for calibration or troubleshooting.

Table 2-5. Other Related Equipment

ITEM	DESCRIPTION
Fluke Model 2281A Extender Chassis	Allows adding extra channels by housing additional option assemblies.
Fluke 2281A-402 Extender Chassis Cable	Cable to connect a Front End to a 2281A Extender Chassis or to link two 2281A Extender Chassis. Ordered in lengths from 1 to 1000 meters.
Fluke 2281A-403 Connectors for Extender Chassis Cable	Connectors for each end of a 2281A-402 Cable. Installed onto the cable at the factory.
Fluke 2281A-431 Power Supply for the 2281A Extender Chassis	Optional power supply for the 2281A Extender Chassis. Used for remote operation in some cases.
Fluke Accessories Y1702, Y1703 and Y1705 Null Modem Cables	Used to direct connect the Front End with the host computer. Three lengths
Fluke Accessories Y1707 and Y1708 RS-232-C Cables	Used to connect the Front End to another RS-232-C device. Two lengths.

SHIPPING INFORMATION

When you receive the instrument, inspect the shipping container for any possible shipping damage. Special instructions for inspection and claims are included on the shipping container.

If it is necessary to reship the instrument, use the original container. If the original container is not available, a new one can be obtained from the John Fluke Manufacturing Co., Inc. upon request.

SERVICE INFORMATION

The Front End is warranted for a period of one year upon delivery to the original purchaser. The warranty is located, in the front of this manual, after the title page.

Factory calibration and service for each Fluke product is available at various locations worldwide. A complete list of these service centers is given in Section 10 of this manual. If requested, an estimate will be provided to the customer before any work is begun on an instrument whose warranty period has expired.

Maintenance plans are available to maintain the Front End at your site, to supplement the normal warranty period, or to do both. For specific information, contact your nearest Fluke Technical Service Center or Sales Representative.

CONTENTS

INTRODUCTION

Section 3 provides the theory of operation for the Helios I Computer Front End mainframe. The theory of operation is complemented by block diagrams, simplified schematics, and tables, which aid in clarifying concepts. Schematic diagrams for the Motherboard and Computer Interface Assembly are in Section 7. When unfolded, a schematic diagram remains fully visible while the manual is open to any preceding page. This arrangement is useful when simultaneously reading the theory of operation and viewing related areas of the schematic diagram.

Section 3 covers only the theory of operation. Installation, operating, and configuration instructions for the Front End are located in the Helios I System Manual.

The Scan/Alarm Option (-201) uses a different Computer Interface Module than described in this section. Refer to Section 9A for the related theory of operation. All the other following theory in Section 3 applies to both versions of the Front End (with or without Scan/Alarm option).

Many optional modules and connectors are available. These provide the Front End with specific measurement and control functions. Theory of operation and a schematic diagram for each optional assembly and connector are provided in the subsection of Section 8 or Section 9 devoted to that option.

OVERALL FUNCTIONAL DESCRIPTION

To help clarify the relationship of the Front End's major functional blocks, refer to Figure 3-1 (a simplified block diagram of the Front End) while reading the overall functional description.

Blocks that are drawn in dashed lines represent optional assemblies; these assemblies are not required. However, any useful system will contain at least one data acquisition or control option, hereafter collectively referred to as serial link devices. These options can include, for example, the a/d converter, digital I/O, and analog I/O.

The serial link allows the CPU of the Front End mainframe to communicate with all measurement and control options in the system. The serial link can be extended outside the Front End Chassis to an Extender Chassis that also contains serial link device options. To communicate with the optional assemblies, the serial link uses RS-422 signals that are sent and received through two pairs of conductors. Through one pair, the computer interface transmits while the options listen. Through the other pair, the selected option can transmit only to the computer interface.

The following summary breaks down the Front End into its three major circuit blocks and briefly describes the function of each. The circuit analysis explains in detail how each of these three blocks operates.
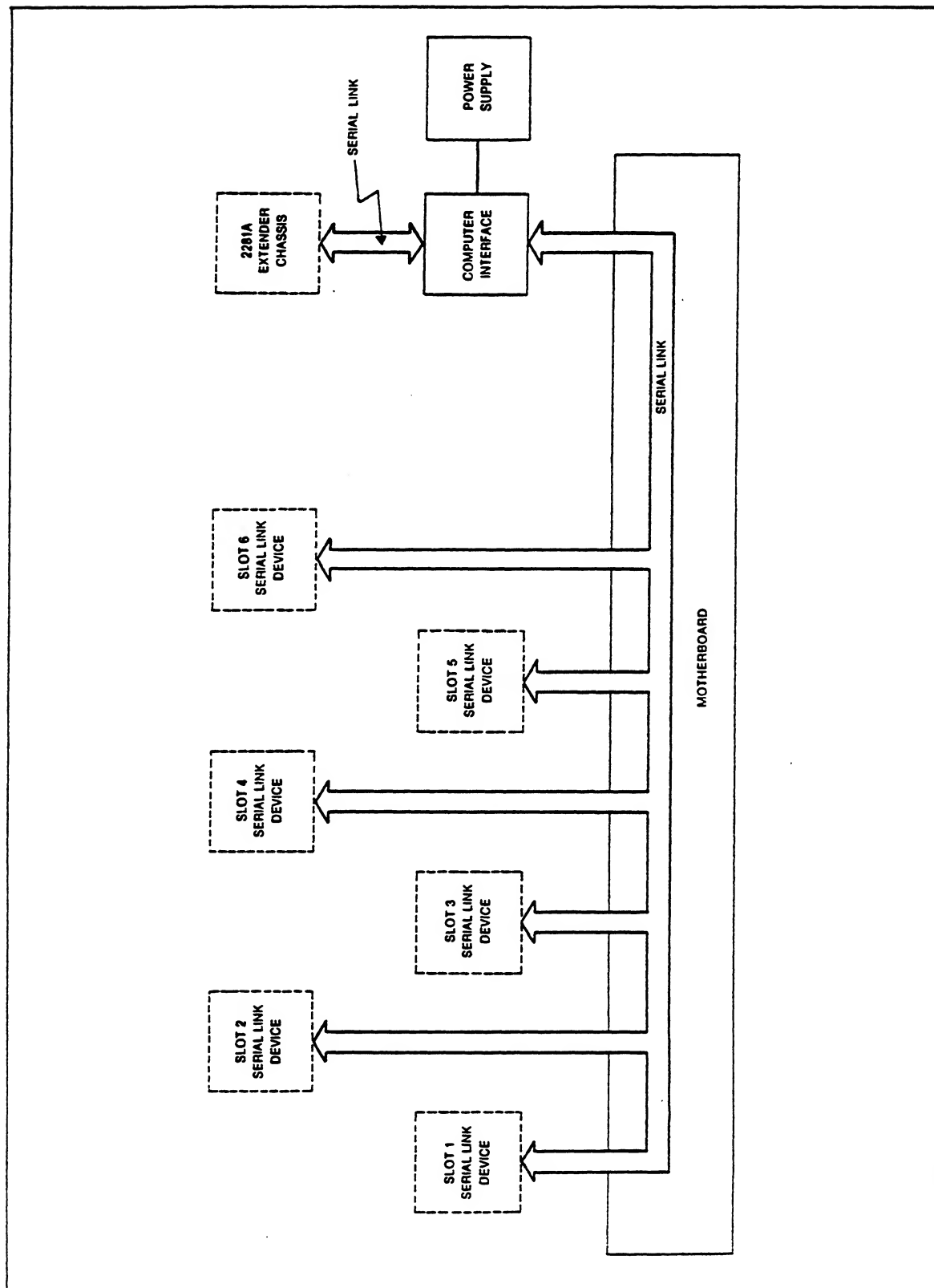
Figure 3-1. Mainframe Assemblies Block Diagram

o   Chassis Motherboard

The chassis Motherboard provides the interconnection between the
Computer Interface Assembly and the serial link devices. It also,
provides interconnection between A/D options and scanner options
that are associated with the A/D.

o   Computer Interface Assembly

At the heart of the Front End is the Computer Interface Assembly.
The Computer Interface Assembly is centered on the TMS-9995
microprocessor. This assembly provides the interface between the
host computer and the measurement and control options. Commands
from the host computer are interpreted and the appropriate
responses are. executed by the Computer Interface Assembly.

o   Power Supply

The power supply converts ac power into three regulated dc output
voltages that provide power for all assemblies within the Front End
and for serial link options installed in an Extender Chassis. The
number of serial link options that can receive power from the
mainframe power supply is limited. Further information on supplying
power to these options is contained in Section 3, "Installation and
Setup," of the Helios I Computer Front End System Manual.

More complete discussions of each of these major circuit blocks follow.

CHASSIS MOTHERBOARD

The Motherboard interconnects the Computer Interface Assembly and the
serial link devices installed in the mainframe or extender chassis.

PCA card-edge connectors are mounted on one side of the Motherboard.
Since the Motherboard PCA is designed to be used in other instruments,
there are several places (not used by the Front End) where additional
connectors can be mounted.

The schematic diagram for the Motherboard (see Section 7) contains
information about all card-edge connectors that can be installed on the
Motherboard. Therefore, the schematic shows several signal names that
can be ignored. Connector J12 is used for connection to the Computer
Interface Assembly and is labeled on the schematic as power supply. The
only connections on J12 which are used are: RX+ (43), RX- (41), TX+
(44), TX- (42), GND1 (17, 18, 19, 20), GND3 (25, 26, 27, 28) and +24
(22,23).

Although the +24V line is used to supply power to the serial link
devices, the Front End power supply actually supplies 12V. The serial
link devices will operate off 10 to 25V.

COMPUTER INTERFACE ASSEMBLY

Figure 3-2 is a functional block diagram of the Computer Interface Assembly. This assembly can be thought of as consisting of 15 functional circuit blocks.

The discussion of the Computer Interface assembly begins with a functional description of the assembly as a whole, followed by a more specific discussion of each of the 15 functional blocks.

The CPU, which controls operations on the Computer Interface Assembly, is a TMS-9995 microprocessor. The TMS-9995 interfaces with ROM and RAM in the conventional manner and with various I/O devices through a communications register unit (CRU) and the address lines.

At power-up, the reset circuit initializes various circuit elements and keeps the CPU from operating until the supply voltage is within operational limits. When reset is released, the CPU begins execution as directed by the ROM.

The CPU initializes the system based on: 1) configuration switch settings, 2) data which remains in the non-volatile RAM during the power-down state, and 3) information about serial link devices that are detected through the serial link communication interface.

After initialization is complete, the host communication interface is ready to accept commands from the host and pass them on to the CPU for interpretation and execution. Commands from the host can result in placing data into RAM, reading and returning data from RAM, setting or reading the clock data, or performing a measurement or control function on a serial link device.

A description of each of the 15 functional blocks which make-up the Computer Interface Assembly follows.

Power ON/OFF Reset Circuit

The power ON/OFF reset circuit monitors the +5V power supply and asserts RESET(L) when the voltage is below 4.6V. U16 is powered from the +5B supply, which is backed up by battery if the power is OFF. This allows RESET(L) to be actively asserted when power is OFF, and it is used by the memory chip selector block to ensure that the RAMs are de-selected while the power is below 4.6V.

R24 and R26 form a precision voltage divider off the +5V supply. The output of the voltage divider is compared by U16 (a dual-voltage comparator) to 1.23V, which is produced by R27 and VR2 (a band-gap reference diode). On power-up, when the +5V supply has reached 4.6V, U16 removes the common on pin 1 and lets C14 begin to charge through R28 to the +5V supply. When the voltage across C14 reaches 1.23V, U16

Figure 3-2. Computer Interface Assembly
(Functional Block Diagram)

removes the common on pin 7, and RESET(L) is pulled to the +5V supply through R25. The time constant of C14 and R28 is short enough to ensure that the output pin 7 of U16 will transition without bounces and long enough to filter any bouncing that might occur when the first stage of U16 transitions.

Test Circuit

Part of U9 and U8 is used to form an R/S flip-flop, which can be used to stop and start CPU instruction execution.

The CPU is stopped by momentarily applying a low to pin 3 of J74, and it is started again by momentarily applying a low to pin 1 of J74.

Central Processor Unit (CPU)

The CPU is implemented by U20, a TMS-9995 16-bit microprocessor. The TMS-9995 onboard clock generator uses Y1, an 11.9808 MHz crystal, to determine the frequency of the clock. C18 and C19 are used to ensure proper capacitive loading for the onboard amplifiers.

Pull-up resistor, R32, de-asserts the HOLD(L) input on the TMS-9995 since this feature is not implemented.

Pull-up resistor, R33, asserts the READY input on the TMS-9995. When RESET(L) makes a low-to-high transition at power-on with READY asserted, the automatic first wait state generation feature of the TMS-9995 is selected. This causes one wait state to be added to every memory access cycle.

Data and Address Buffers

The 8-bit data bus is buffered by U30, an octal bus transceiver. The direction of data transfer is determined by the CPU control signal DBIN(L). This buffer, which is required due to the large number of memory ICs used in the Front End, is enabled only when DBIN(L) and MEMEN(L) are asserted.

The 16-bit address bus is buffered by octal buffers U21 and U31. These buffers are required due to the large number of memory ICs and CRU devices used in the Front End.

CPU Control Buffers and Logic

The CPU control signals MEMEN(L), WE(L)/CRUCLK(L), DBIN(L), and CLKOUT are buffered by U29, an octal buffer. This buffer is required due to the large number of memory ICs and CRU devices used in the Front End.

A buffered MEMEN(L) from U29, pin 9 is used on U30, pin 19 to enable the data bus buffer.

One of the inverters of U8 is used to generate the complement of WE(L)/CRUCLK(L) as required by some of the CRU devices.

Communication Register Unit (CRU) Device Selector Circuit

Figure 3-3 shows a schematic diagram of the CRU device selector circuit block. This circuit detects a CRU device input or output cycle by the CPU and selects the device based on the address bits A6 through A8.
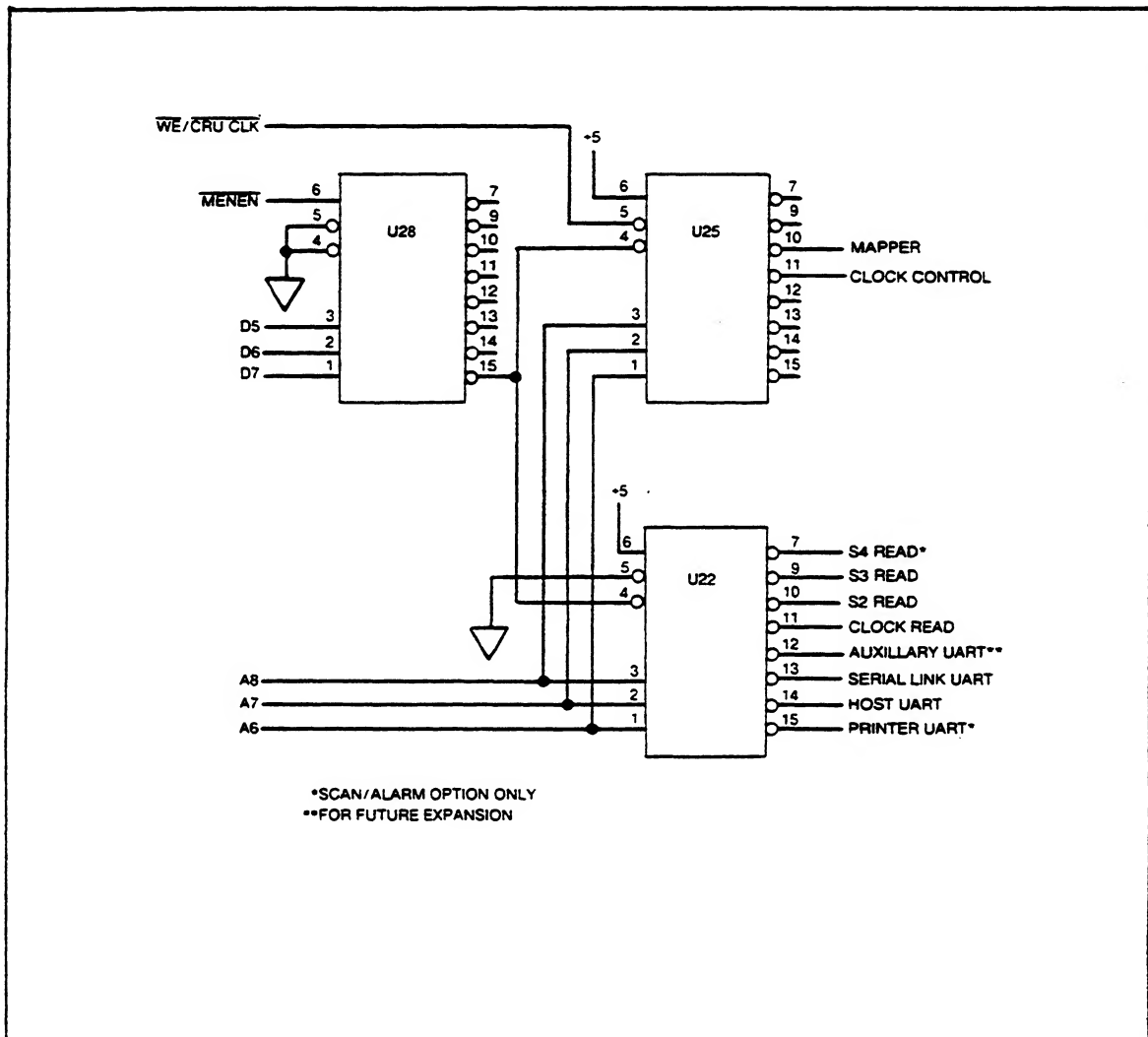
Figure 3-3. CRU Device Selector Circuit

When the data bits D5 through D7 are low and the control signal MEMEN(L) is high, U28 pin 15 will be low. Since the enable inputs on U22 pins 4, 5, and 6 are all asserted, the U22 output corresponding to the address bits A6 through A8 will be low. When the CRUCLK(L) control signal is low, all the enable inputs on U25 pins 4, 5, and 6 are asserted and the output corresponding to the address bits A6 through A8 will be low. In other words, when the CPU is requesting communication with a CRU device, one output of U22 will be low and one output of U25 will follow CRUCLK(L).

Table 3-1 shows the base address, the CRU device that is selected, and the type of transaction.

Table 3-1. CRU Device Selection

ADDRESS	INPUT	OUTPUT
0x0000	Printer Port	Printer Port
0x0040	Host Port	Host Port
0x0080	Serial Link	Serial Link
0x00C0	Auxiliary Port	Auxiliary Port
0x0100	Clock & Misc	Clock & Alarm
0x0140	Switch 2	Mapper & Misc
0x0180	Switch 3	Not Used
0x01C0	Switch 4	Not Used

Of the four ports that can be selected, the standard configuration Front End uses only the host and serial link ports. On the Scan/Alarm option (-201), switch 4 is used for the printer port.

The CRU device selector circuit can select multiple CRUs simultaneously. However, pins 10 and 11 on U22 enable CRU devices that are for input only, and pins 10 and 11 on U25 enable CRU devices that are for output only. When an output device is receiving data from the CPU and the CRUCLK(L) signal is toggling, the input-only device of the same address that is enabled by U22 will be inactive since DBIN(L) is high. When an input device is sending data to the CPU, the CRUCLK(L) signal is high and none of the outputs of U25 will be asserted.

Memory Chip Selector Circuit

The memory chip selector circuit decodes the address bus and other inputs from the CPU via a CRU device to select one of 14 memory ICs for data transfer.

The CPU has the ability to address directly 64K bytes of memory with the 16-bit address bus. This address space contains EPROM (Erasable Programmable Read-Only Memory) and RAM (Random-Access Memory). Since the Front End requires more RAM for parameter and data storage than can be accommodated by this 64K-byte address space, part of the memory space is multiplied by using banks.

Figure 3-4 shows how the memory is organized.

U32, a 3-to-8 line decoder/multiplexer, asserts the output that corresponds to address bits A13 through A15 when the CPU control signal MEMEN(L) is asserted low.

Table 3-2 shows the relationship between the address bits and the chip that is selected.
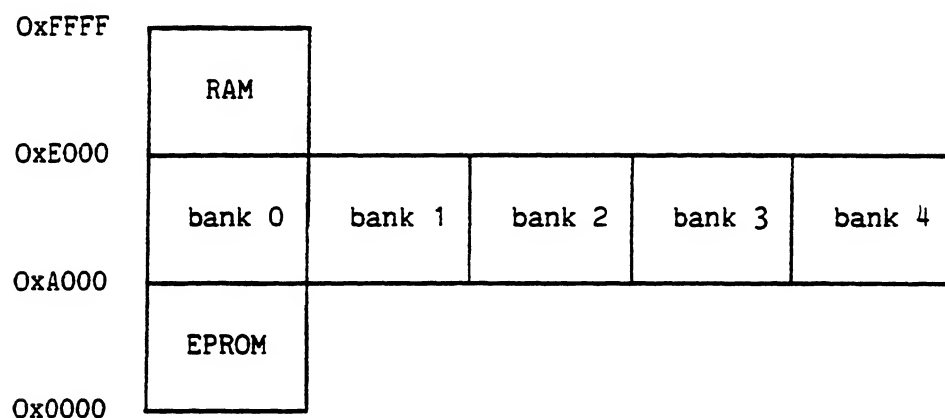
NOTE: RAM bank 4 is not used by the Front End. It is available for future expansion.

Figure 3-4. Memory Organization

Table 3-2 Address Bits and Chip Selection

ADDRESS RANGE	U32 PIN ASSERTED	CHIP SELECTED
0x0000-0x1FFF	15	U46 (EPROM)
0x2000-0x3FFF	14	U49 (EPROM)
0x4000-0x5FFF	13	U45 (EPROM)
0x6000-0x7FFF	12	U48 (EPROM)
0x8000-0x9FFF	11	U44 (EPROM)
0xA000-0xBFFF	10	U27 (Bank selector)
0xC000-0xDFFF	9	U24 (Bank selector)
0xE000-0xFFFF	7	U47 (RAM)

When selected by U32, the 3-to-8 line decoder/multiplexers, U24 or U27 will assert the output that corresponds to the signals on the input pins 1, 2, and 3. These inputs are supplied as signals MM0 through MM2 from U26, an 8-bit addressable latch, which is used as a CRU output device. The CPU selects the proper bank for the data transaction and sets the bits into the appropriate outputs of U26 prior to accessing the RAM.

Table 3-3 shows the relationship between the mapper bits MM0 through MM2 and the RAM chip that is selected.

Table 3-3. Mapper Bits and RAM Chip Selection

MM2	MM1	MM0	U24 OR U27 PIN ASSERTED	RAM SELECTED IF U24 ENABLED	RAM SELECTED IF U27 ENABLED
0	0	0	15	U36	U38
0	0	1	14	U41	U43
0	1	0	13	U35	U37
0	1	1	12	U40	U42
1	0	0	11	U39	U34

U24 and U27 are CMOS ICs and have power applied from the +5B supply when Front End power is OFF. The enable input on pin 6 of U24 and U27 is connected to the power ON/OFF reset circuit. When the +5V supply is below 4.6V, the RESET(L) signal is asserted low, which de-selects U24 and U27, which in turn de-select all the banked RAMs. This ensures non-volatile memory retention of parameters and data. The inputs of U24 and U27 are pulled to the +5V supply by resistors in network Z6, since the drive signals originate from TTL-LS ICs.

Outputs on U26 pins 7 and 9 are made available for future expansion as additional mapper bits, and are not used by the Front End. Outputs on U26 pins 10, 11, and 12 are used to provide inputs from the CPU to the host communication interface circuitry.

The CPU sets the outputs of U26 with a CRU output cycle. The RESET(L) signal asserted at power up on U26 pin 15, CLEAR, causes all outputs to be set low. The address of the latch to be written to is from address bits A1 through A3, and the state of the latch is defined by address bit A0. The CRU device selector circuit supplies the enable input on U26 pin 14 as discussed above.

Read-Only Memory (ROM)

The Read-Only Memory that supplies the firmware for the CPU consists of five 8K-byte by 8-bit EPROMs (U44, U45, U46, U48, and U49).

The data in these EPROMs is retrieved by a CPU read cycle. Address bits A0 through A12 are decoded by each EPROM to determine the byte being fetched. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 to provide the chip-select signal to pin 20 on one of the five EPROMs. The selected EPROM outputs data to the data bus when OE(L) is asserted low; OE(L) is the same as DBIN(L).

Capacitors C29, C30, C31, C38, and C39 are power supply bypass capacitors which reduce noise coupling through the power distribution circuit.

Wire jumpers W1, W2, W3, W5, and W6 are hardwired on the Computer Interface PCA as shown on the schematic diagram. These jumpers are provided for future modification and can be ignored.

Random-Access Memory (RAM)

The Random-Access Memory used by the CPU consists of nine 8K-byte by 8-bit CMOS static RAMs (U35 through U38, U40 through U43 and U47).

These RAMs are powered by the +5B (battery backed up) power supply so that the data is non-volatile when the power is OFF. The power ON/OFF reset circuit and the memory selector circuit ensure that the chip select input pin 20 is de-asserted high when the +5V supply is below 4.6V.

Data is written into these RAMs by a CPU write cycle. Address bits A0 through A12 are decoded by each RAM to determine the byte being written to. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 and the memory mapper, U26, bits MM0 through MM2 to provide the chip select signal to pin 20 on one of the nine RAMs. The data on the data bus is written into the selected byte of the selected RAM when WE(L) is asserted low.

The data in these RAMs is retrieved by a CPU read cycle. Address bits A0 through A12 are decoded by each RAM to determine the byte being fetched. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 and the memory mapper, U26, bits MM0 through MM2 to provide the chip select signal to pin 20 on one of the nine RAMs. The selected RAM outputs data to the data bus when OE(L) is asserted low: OE(L) is the same as DBIN(L).

Capacitors C22, C23, C25, C27, and C33 through C37 are power supply bypass capacitors which reduce noise coupling through the power distribution circuit.

Wire jumpers W4 and W7 on the Computer Interface PCA are as shown on the schematic diagram for the standard Computer Interface Assembly. Refer to Section 9A for Scan/Alarm option use of these jumpers.

Sockets for U34 and U39 and associated power supply bypass capacitors C21 and C32 are not used with the standard Computer Interface Assembly and can be ignored. Refer to Section 9A for Scan/Alarm option use of these components.

Configuration Switches and Interface Circuit

The circuit block containing the configuration switches and interface circuit consists of CRU devices and DIP switches for the input of configuration information to the CPU. There are three identical circuits in this block and each operates the same; however the data obtained is for different use by the CPU. Switch pack S2, pull-up resistor network Z1, and data selector/multiplexer U15 are used to provide information about the host computer communication port. Switch pack S3, pull-up resister network Z2, and data selector/multiplexer U23 are used to provide information about the host computer protocol and local line frequency. Switch pack S4, pull-up resistor network Z3, and data selector/multiplexer U33 are not used by the standard Computer Interface Assembly. They are used with the Scan/Alarm option, which is documented in Section 9A of this manual.

When the CRU device selector circuit detects that the CPU is accessing this circuit, the appropriate output of U22 asserts the strobe input, pin 7, of the data selector/multiplexer U15 or U23. Address bits A1 through A3 are used to address each switch that is connected with a pull-up resistor to each input of U15 or U23.

If the selected switch is closed, a low is output on pin 5 of the enabled data selector/multiplexer. If the selected switch is open, a high is output on pin 5 of the enabled data selector/multiplexer. These pin 5 outputs are the CRUIN signal for the CPU and will be input while DBIN(L) is asserted low.

The function of each switch is shown on the decal located on the rear bezel of the Front End.

This circuit is only used at power-up. Therefore, if the configuration is changed, the power to the Front End must be cycled for the CPU to be reconfigured.

Clock and Clock Interface Circuit

The clock and clock interface circuit provides the Front End with a non-volatile system clock and calendar. U19 is a CMOS calendar/clock IC that is powered from the +5B (battery backed up) power supply. Interface to the CPU is provided by CRU devices for control and reading of the clock.

The CRU device that allows the CPU to output control signals and data to U19, is U18, an 8-bit addressable latch. The CPU sets the outputs of U18 with a CRU output cycle. The RESET(L) signal asserted at power-up on U18 pin 15, CLEAR, causes all outputs to be set low. The address of the latch to be written to is from address bits A1 through A3 and the state of the latch is defined by address bit A0. The CRU device selector circuit supplies the enable input on U18 pin 14 as discussed above.

When the CRU device selector circuit detects that the CPU is accessing this circuit to read data, the output of U22 pin 11 is asserted low and provides the strobe input, pin 7, of U17, a data selector/multiplexer.

Table 3-4 defines the signals used for control and setting of U19.

Table 3-4. U19 Control Signals

CRU ADDRESS	U18 PIN	U19 PIN	SIGNAL
0x0100	4	3	Address 0
0x0101	5	2	Address 1
0x0102	6	1	Address 2
0x0103	7	5	Device Select
0x0104	9	4	Command Strobe
0x0105	10	8	Shift Clock
0x0106	11	6	Clock Data Input

The control inputs on U19 are set by the CPU through U18 so that a bit of data from the clock is present on U19 pin 9 which is input to the CPU via U17 pin 4 by a CRU input cycle that addresses this input.

U17 is also used to input data from the communication interface circuit blocks.

Clock frequency is controlled by Y2, a 32.768 kHz crystal. Capacitors C15 and C16 are required to maintain oscillator operation and stability. Resistor R31 is a pull-up resistor for the clock data output on U19 pin 9, since this output is open drain.

Host Communication Circuit

The host communication circuit provides the interface between the CPU and the serial, asynchronous, communication channel with the host computer. The line driver and receiver portion of the circuit can be switch selected to EIA voltage levels with RS-232-C protocol or RS-422 differential voltage levels.

Data exchange with the CPU is done with a TMS-9902A asynchronous communications controller (ACC), using the CRU interface hardware.

The ACC, U14, is enabled at pin 17 when the output of U22 pin 14 is asserted low, which will happen when the CPU is sending data to or receiving data from the ACC. The CPU sends control information and data to the ACC on a CRU output cycle. The CPU receives control information and data from the ACC on a CRU input cycle. The identification of each bit of data transferred is determined by addresses A1 through A5 with the state of the data for the ACC defined by address bit A0, and the state of the data for the CPU defined on pin 4 of the ACC.

The connection between the Front End and the host computer is made through connector J70. A six-position DIP switch, S1, is used to select between EIA RS-232-C and RS-422 communication types.

RS-232-C COMMUNICATION

When RS-232-C communication is used, the host sends characters to J70 pin 3. The EIA voltage-level signal is converted to TTL signal levels by U6, a quad line receiver, and passed to U14 pin 3. When the ACC detects that a character has been received, the CPU is notified with an interrupt and inputs the character from the ACC. The Clear to Send (CTS) and Data Set Ready (DSR) signals from the host computer are level shifted by U6 and passed to U14 on pins 7 and 6, respectively. When the ACC has a character to send to the host computer, the signal is output with the configuration switch-selected characteristics on pin 2 of U14, the ACC. This TTL-level signal is converted to EIA voltage levels by U5, a quad line driver, and passed to J70 pin 2 for reception by the host computer. The Request to Send (RTS) signal from U14 pin 5 is level shifted by U5 and passed to J70 pin 4. This communication will take place provided all of the RS-232-C control signals are asserted properly. If a "three wire connection" is used to the host, U6 is biased to interpret these open inputs as asserted and provides the appropriate control inputs to U14, the ACC. Capacitors C3, C7 and C8 along with resistors in resistor networks Z4 and Z5 provide noise filtering at U6.

RS-422 COMMUNICATION

When RS-422 communication is used, the host sends characters to J70 pins 14 and 15. The differential voltage input is converted to TTL signal levels by U3, a dual differential line receiver, and passed to U14 pin 3. The response of U14 from this point is the same as for RS-232-C. An output character from the ACC, is converted from TTL levels to a differential voltage level by U7, a dual differential line driver, and passed to J70 pins 9 and 10. Line drive is improved by using both drivers of U7 in parallel and resistively coupling their outputs with R16 through R19 to allow for a non-fatal driver failure. Resisters R20 and R21 provide current limit protection. Resistors R13 and R15 provide line termination for receive inputs. Resistors R12 and R14 provide a defined input for U3 when the inputs are left open.

Serial Link Communication Circuit

The serial link communication circuit provides the interface between the CPU and the RS-422 serial communication channel with its associated measurement and control options (referred to as serial link devices).

Data exchange with the CPU is done with a TMS-9902A asynchronous communications controller (ACC), using the CRU interface hardware.

The ACC, U11, is enabled at pin 17 when the output of U22 pin 13 is asserted low, which will happen when the CPU is sending data to or receiving data from the ACC. The CPU sends control information and data

to the ACC on a CRU output cycle. The CPU receives control information and data from the ACC on a CRU input cycle. The identification of each bit of data transferred is determined by addresses A1 through A5 with the state of the data for the ACC defined by address bit A0, and the state of the data for the CPU defined on pin 4 of the ACC.

The interconnection of the Computer Interface Assembly and serial link devices installed in the Front End is made through P12 (via the Motherboard PCA). The interconnection of the Computer Interface Assembly and serial link devices installed in Extender Chassis is made through J23 (via appropriate cabling).

A character for serial link output that has been transferred to U11, the ACC, is serially output by U11 on pin 2 and converted from TTL levels to RS-422 differential voltage levels by U1, a dual differential line driver. Line drive is improved by using both drivers of U1 in parallel and resistively coupling their outputs with R4 through R7 to allow for a non-fatal driver failure. CR4 through CR7 provide voltage protection for U1, and R2 and R3 provide current limit protection.

A character for input from a serial link device is converted from differential voltage levels to TTL-levels by U3, a dual differential line receiver, and passed to U11 pin 3. When U11 detects that a character has been received, the CPU is notified with an interrupt and inputs the character from the ACC. Resistors R8 through R11 provide line termination for the receive inputs. Diodes CR8 through CR11 provide voltage protection for U3.

Interrupt Control Logic

The serial link ACC is operating at 25,000 baud, so the interrupt on pin 1 is connected directly to the INT1(L) input of U20, pin 15.

The host computer ACC interrupt on pin 1 is low OR-ed by U9 with other possible ACC interrupts to produce a composite interrupt on U9 pin 12 that is connected to the INT4(L) input of U20, pin 14. Since U12 and U13 are for future expansion, R22 and R23 pull-up resistors are used to keep these interrupt lines from floating. The INT1(L) input on U20 has a higher priority than the INT4(L) input.

Power Distribution

Power is delivered to the Computer Interface Assembly from the mainframe power supply by an 8-conductor cable that connects at J75. TP1 through TP4 are provided to monitor the +5V, +12V, and -12V power sources at the Computer Interface Assembly. VR1, a 6V Zener diode, provides protection against voltage transients.

When Front End power is ON, and W9 (the battery power disconnect jumper) connects the negative terminal of the battery to ground, the +5V supply provides +5B through CR1 and charges BT1 through R1 and CR3. When Front End power is OFF, the battery (BT1), supplies +5B through CR2.

POWER SUPPLY

The power supply is a switch mode supply that operates at either 90 to 132V ac or 180 to 264V ac (depending on a jumper setting), at a frequency range between 47 through 440 Hz.

The ac line voltage is transformed to regulated +5V, +12V and -12V dc voltages. The power supply connector pinouts are shown in Table 3-5.

Table 3-5. Power Supply Connector Pinouts

J1 (INPUT)		J2, J3, & J4 (OUTPUT)	
PIN	SIGNAL	PIN	SIGNAL
1	AC Neutral	1	-12V
2	AC Line	2	+12V
E3	AC Ground	3	Return
		4	+5V

See Section 7 of this manual for a schematic diagram of the power supply.

SERIAL LINK COMMUNICATION

Hardware

The serial link connects the Computer Interface Assembly with data acquisition and control options in the system.

NOTE

In this discussion, the data acquisition and control options are collectively called "devices."

The serial link controller (i.e., Computer Interface Assembly) translates TTL-level signals from the CPU into RS-422 signals for communication with the devices. The RS-422 signals are sent and received over two twisted pairs of conductors. On one pair, the controller transmits while all devices listen. On the other pair, a device selected by the controller can transmit responses to the controller, but never to other devices.

Devices on the serial link may be physically located inside the Front End or in an Extender Chassis. The serial link is routed through each device in such a way that if power is removed from any of them, communication through the link remains unbroken.

General Protocol

This description deals only with the elements of the serial link protocol that are device independent. Because of the diversity of devices, only the most basic protocol can be covered.

Information is sent over the serial link in the form of ASCII characters at a rate of 25000 baud. Each character consists of the following:

    1 Start Bit
    8 Information Bits
    1 Odd Parity Bit
    1 Stop Bit

When the controller sends a message, the addressed device replies with either an acknowledgement or a response message (depending on the message type). A device never initiates an exchange.

A message is sent in one or more groups. The group is the basic protocol unit and consists of three information characters followed by a check character. Some controller messages require the device to reply with an acknowledgement, which is a single character and can have one of only two values: ready (0x3C), and not ready (0xC3).

The serial link is protected against occasional errors in transmission by character parity and longitudinal parity. The protocol recovers by repeating the transmission.

static awareness

A Message From
Fluke Corporation
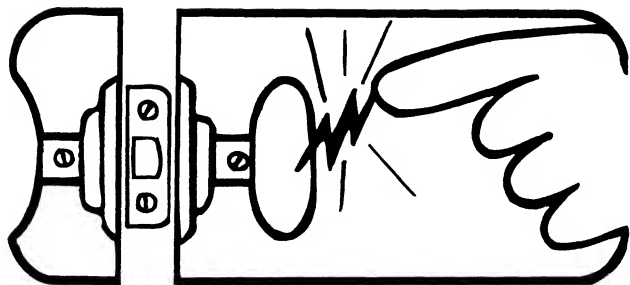
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Leaning the guidelines for handling them.
3. Using the procedures, packaging, and bench techniques that are recommended.

The following practices should be followed to minimize damage to S.S. (static sensitive) devices.
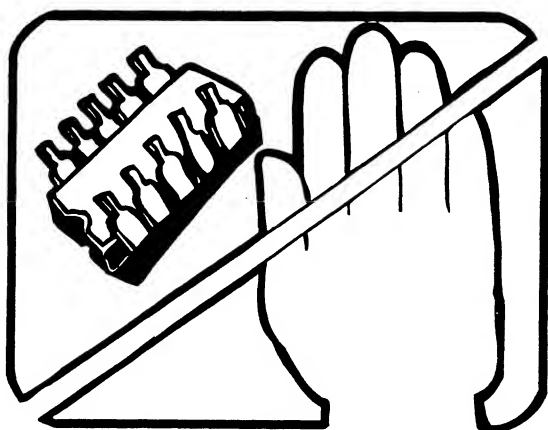
1. MINIMIZE HANDLING
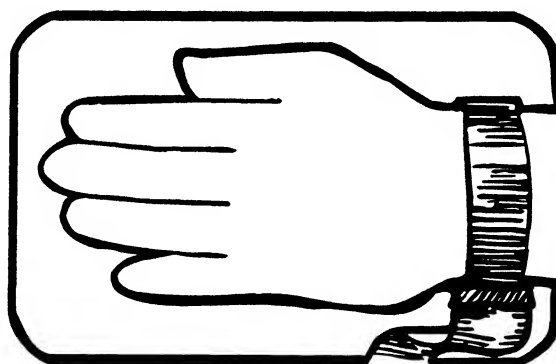
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.
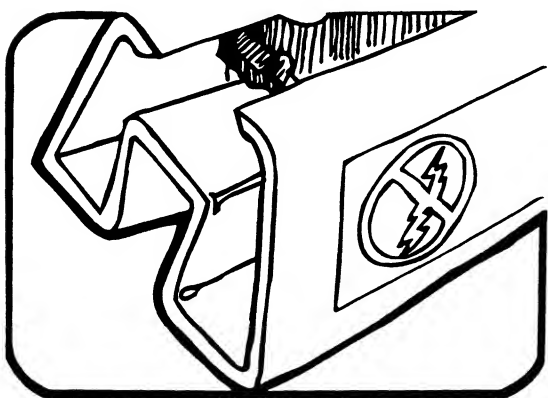
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.
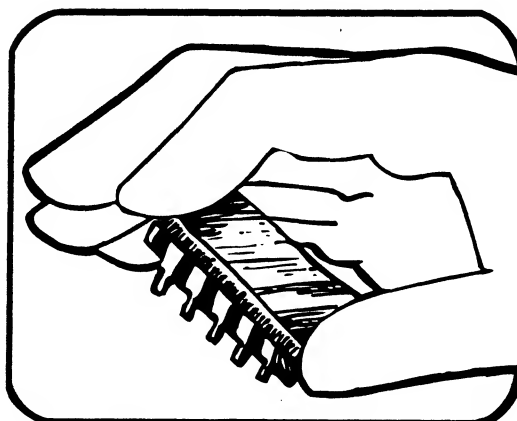
4. HANDLE S.S. DEVICES BY THE BODY.
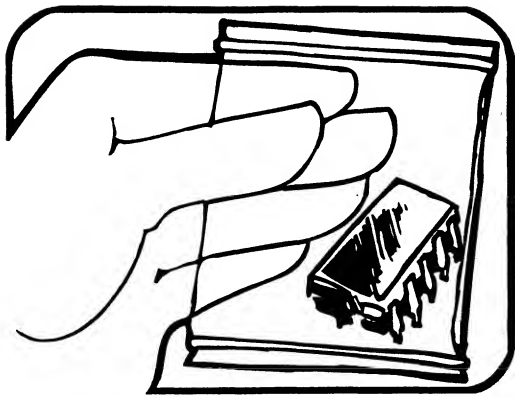
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT.
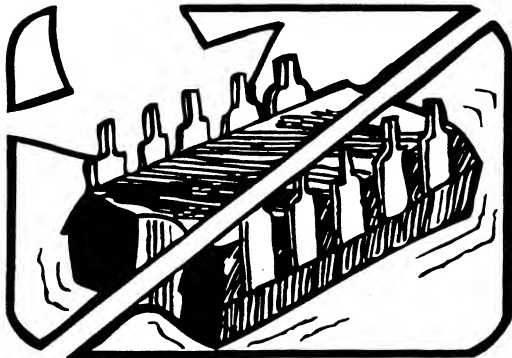
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE.
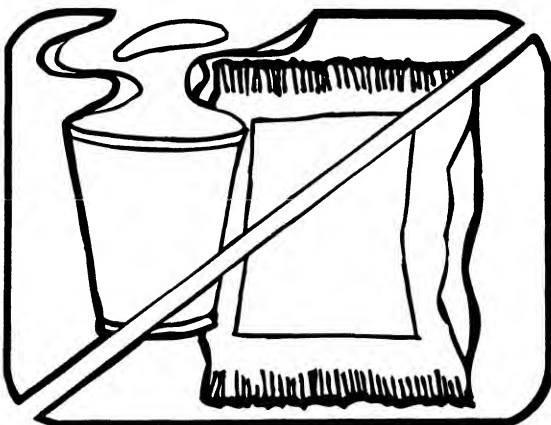
7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA.
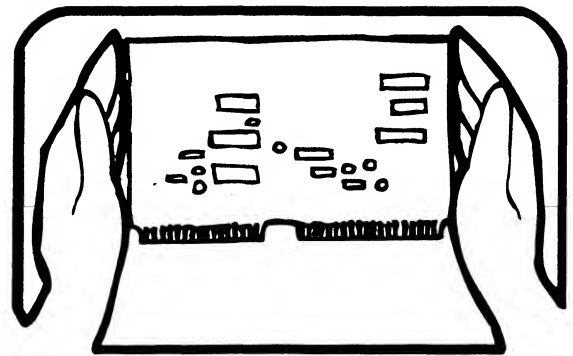
8. WHEN REMOVING PLUG-IN ASSEMBLIES HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS PROTECT INSTALLED S.S. DEVICES.
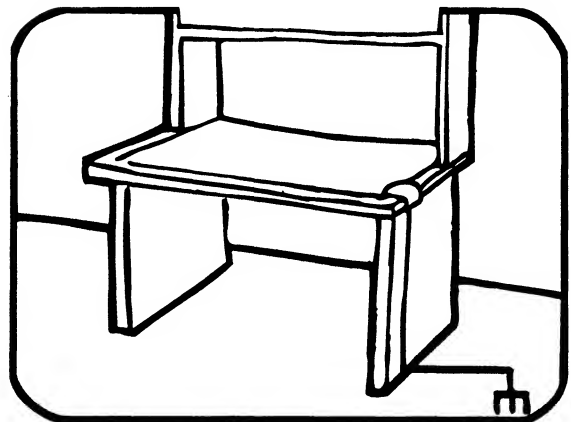
9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION.

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED-TIP SOLDERING IRONS SHOULD BE USED.

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CONTENTS

INTRODUCTION

Section 4 contains procedures for performing general maintenance on and accessing and cleaning all major assemblies of the Front End mainframe.

NOTE

If the Front End is equipped with a Scan/Alarm option (-201), a different Computer Interface Assembly is used. Related maintenance instructions are found in Section 9A of this manual.

GENERAL MAINTENANCE

Line Voltage Selection

Refer to Section 9A for Scan/Alarm Option -201 line voltage selection instructions.

WARNING

THE FOLLOWING PROCEDURE REQUIRES ACCESS TO THE INTERIOR OF THE COMPUTER FRONT END. DO NOT PERFORM THIS PROCEDURE UNLESS YOU ARE QUALIFIED TO DO SO. LETHAL VOLTAGES MAY EXIST WITHIN THE UNIT.

The power input setting (110V or 220V) is normally marked on the support panel of the Computer Interface Module, just above the power input connector. If there is no mark in either box, or if the box is marked for a voltage other than the one you will be using, use the following procedure to gain access to the internal setting.

1. Turn the Computer Front End power switch to OFF.

2. Remove the ac input line cord from the power source and from the Computer Front End.

3. Remove the four Phillips-head screws indicated in Figure 4-1.

REMOVE THESE SCREWS

Figure 4-1. Computer Interface Module Supply Removal Screws

4.   Remove the Computer Interface Module from the chassis by grasping
     the finger indentation in the fan filter hole (as shown in Figure
     4-2) and sliding the module straight back and out.

FAN FILTER
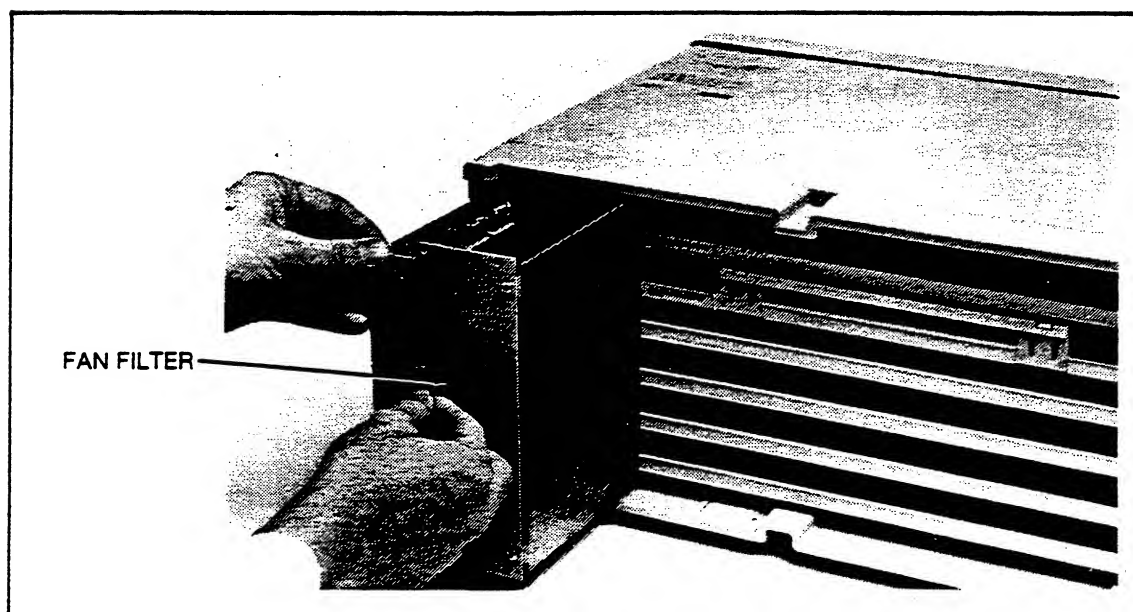
Figure 4-2. Removing the Computer Interface Module

5.   Refer to Figure 4-3 to locate the Line Power Voltage Pins on the
     Power Supply PCA.

     To select 180-264V operation, connect the wire to the pin marked
     220V. For 90-132 operation, place the wire on the pin labeled 110V.

NOTE

It is not necessary to change the power input fuse
when changing the power supply operating voltage.
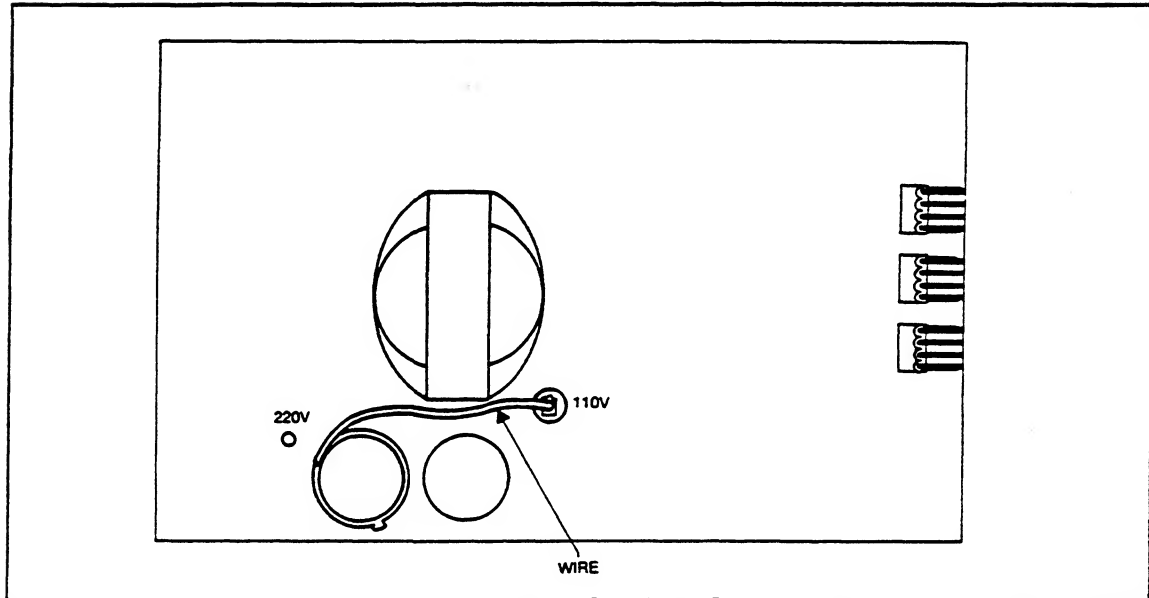
Figure 4-3. Line Power Voltage Pins

6. While the Computer Interface Module is out, locate the Line
    Frequency Selection Switch, S3-8, (see Figure 4-4) to ensure that
    it is set to the local line frequency.

    If the switch is not set to the local line frequency, set it
    properly before continuing. For 50-Hz operation, place S3-8 in the
    0 position (toward the card edge). For 60-Hz operation, place the
    switch in the 1 position.

7. After changing the line power voltage, mark the appropriate power
    setting on the support panel of the module, (above the ac input
    socket where the words "WIRED FOR" are embossed).

8. Slide the Computer Interface Module back into the Front End, and
    reinstall the Phillips-head screws.
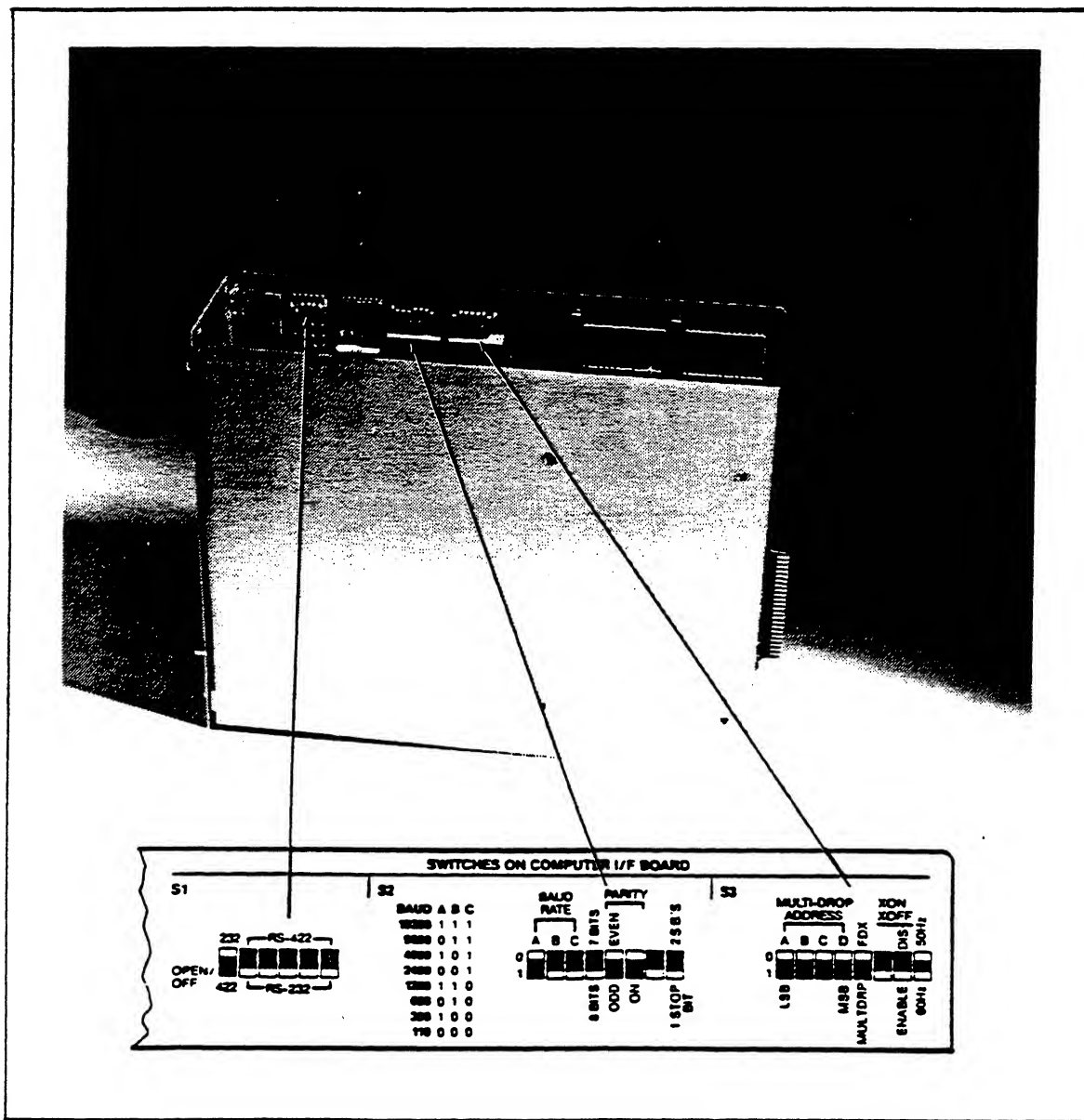
Figure 4-4. Communication Parameter Selection Switches

Fuse Replacement

The fuse is located on a clip-type holder on the power supply assembly, in the corner to the right of the 110V voltage selection pin. When replacing the fuse, use the same value (2.0A, 250V). To check or replace the fuse, perform the following:

1. Switch OFF power to the Front End and disconnect the ac line cord and other high voltage input.

2. Remove the Computer Interface Module as described in steps 3 and 4 of the Line Voltage Selection procedure (above).

3. Use a slotted screwdriver or adjustment tool to remove the fuse.

4. After checking or replacing the fuse, reinstall the Computer Interface Module in the Front End chassis and test its operation.

Power Supply Adjustments

The power supply voltage levels do not normally require calibration, although some minor service adjustments may occasionally be necessary. Refer to Section 5 for power supply adjustment procedures.

General Cleaning

CAUTION

Before cleaning or servicing the Computer Interface Assembly, disconnect back-up battery power by moving the W9 jumper as shown in Figure 4-5.
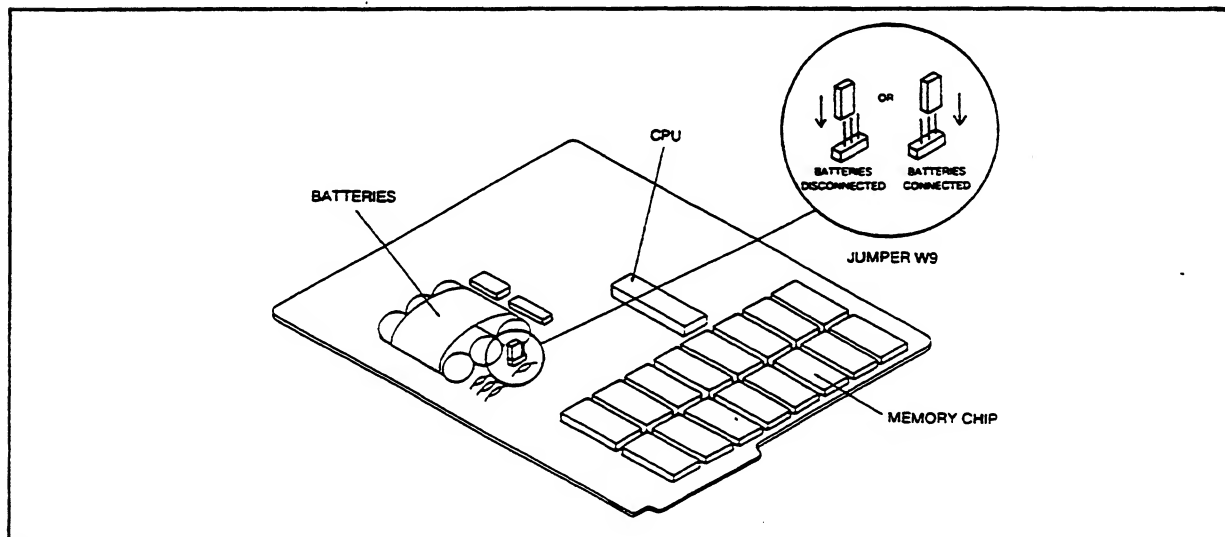
Figure 4-5. W9 Battery Power Jumper

CAUTION

Do not use aromatic hydrocarbons (such as naphthalene) or chlorinated solvents (such as carbon tetrachloride) for cleaning. They may damage plastic materials used in the instrument.

Wipe the Computer Front End periodically to remove dust, grease, and other contamination. The Front End chassis may be wiped using a soft cloth dampened with a mild solution of detergent and water. Dry the case thoroughly after cleaning.

Do not apply fluids or detergents directly to the chassis.

Observe the following precautions when cleaning the Front End:

o   Handle a pca by its edges rather than by its connector pins.

     Oils from your skin can contaminate the board and degrade measurement accuracy of the system.

o   Improper handling can also cause instantaneous or delayed electrostatic discharge damage.

     The yellow "Static Awareness" sheet preceding this section explains some of the hazards of static electricity to sensitive components.

o   Do not use a static-inducing vacuum brush to clean assemblies. Possible electrostatic discharge can damage sensitive components.

PCA Cleaning

Unless dirt, dust or other contamination is visible on its surface, a pca does not normally require cleaning.

When significant dirt or contamination is visible, clean the board(s) with low pressure air (less than 20 psi). If air cleaning is not possible, clean the board with water-based cleaning equipment.

If commercial water-based cleaning equipment is not available, clean the board by holding it under warm, running water.

The Motherboard may be cleaned by removing it (as explained in Section 4, below) and using a FREON degreaser or warm water. Thoroughly dry the Motherboard (use only forced air, not heat) before reassembly.

Observe the following precautions when using water-based cleaning equipment:

1.   Read and observe all precautions listed previously under General Cleaning.

2. Remove all board shielding covers, and separate any relay piggy-back assemblies.

3. In areas with exceptionally hard water, use either deionized or distilled water for a final wash to remove ions left by the hard water wash.

4. Dry all boards thoroughly. Use a low-temperature drying chamber or an infrared drying rack with a temperature range between 100 and 120 °F (38 to 46 °C) if available.

5. If a drying chamber or infrared drying rack is not available, air dry the board at room temperature for a minimum of 48 hours before reassembling.

6. Use a mixture of 70% isopropyl alcohol and 30% water and a lint-free cloth to clean edge-connector contacts. Never use an eraser to clean connector contacts; it might generate static or abrade the gold plating on the contacts.

Fan Filter Cleaning

Clean the fan filter (shown in Figure 4-2) any time it is visibly contaminated. If the Front End is operated too long with a dirty air filter, heat buildup inside could damage sensitive electronic components.

To clean the filter, pinch the center and pull directly out. Clean the filter with warm soapy water and rinse it thoroughly before replacing.

ACCESS, REMOVAL AND REINSTALLATION PROCEDURES

The following procedures provide step-by-step instructions for gaining access to, removing, and reinstalling major assemblies of the Computer Front End Mainframe. Refer to Figure 6-1 for the location of the major assemblies on the Front End chassis.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE FOLLOWING ACCESS PROCEDURES.

Access to Options

Front End module and connector options are accessible from the rear of the instrument.

An option board or connector may be removed by loosening the two retaining screws, one on each side, and sliding out the pca.

Removing and Reinstalling the Top and/or Bottom Cover

Use the following procedure to remove the top and/or bottom cover:

1. Disconnect all power cables and remove any connectors from the serial link options.

2. Remove the carrying straps from the sides of the instrument by removing the two Phillips-head screws at the ends of the handles.

3. Remove the three Phillips-head screws located in the handle indent groove of the cover on each side of the Front End.

4. From the rear of the Front End, remove the top or bottom counter-sunk Phillips-head screw located in the top recess of the rear bezel, and remove the desired cover.

Reverse the previous steps to reinstall the top and/or bottom cover(s).

Removing and Reinstalling the Front Panel

Use the following procedure to remove the front panel from the Front End:

1. Disconnect all power to the Front End.

2. Remove the decals bearing the name Fluke from the sides of the instrument.

3. Remove the three exposed screws from each side of the unit. If the 2289A was rack mounted, remove the rack ears from the side of the instrument and reemove the screws underneath.

4. Pull off the plastic front bezel.

5. Pry off the front panel being careful not to overextend the wire connected to the front panel LED.

6. Desolder LED red and white wires from motherboard noting their locations for reinstallation.

7. From behind the front panel, gently push the LED forward and out.

8. Reinstall the LED before installing the front panel. Push the LED through the hole on the front panel and solder its wires to the motherboard as noted in step #6.

Reverse the previous steps to reinstall the front panel.

Removing and Reinstalling the Motherboard

Use the following procedure to remove the Motherboard from the Front End chassis.

1. Remove the top and bottom covers as described under Removing and Reinstalling the Top and/or Bottom Cover (above).

2. Remove the front panel as described under Removing and Reinstalling the Front Panel (above).

3. Carefully remove the brass gasket from the rear of the unit.

4. Remove the six Phillips-head screws along the outside edge of the unit, and remove the top part of the chassis.

5. Remove the black serial link device card guide.

6. Slide the Motherboard out towards the top of the instrument.

Reverse the previous steps when reinstalling the Motherboard.

To ensure that the Motherboard is reinstalled properly, without damaging it or the Front end chassis, remember to:

o   Reinstall the Motherboard with the P12 connector in the lower left corner as you face the Front End from the rear.

o   Reinstall the device guide with its Motherboard locating peg in the corresponding hole.

o   Reinstall the LED before installing the front panel.

Removing and Reinstalling the Power Supply

Refer to Section 9A for Scan/Alarm Option -201 power supply removal and installation instructions.

WARNING

THERE ARE LETHAL VOLTAGES AT VARIOUS POINTS ON
THE POWER SUPPLY. EXERCISE EXTREME CAUTION WHEN
SERVICING. DISCONNECT THE FRONT END FROM LINE
POWER AND DISCHARGE ALL CAPACITORS AS SOON AS THEY
ARE ACCESSIBLE.

The Power Supply PCA is mounted on the Computer Interface Module (Figure 4-6).
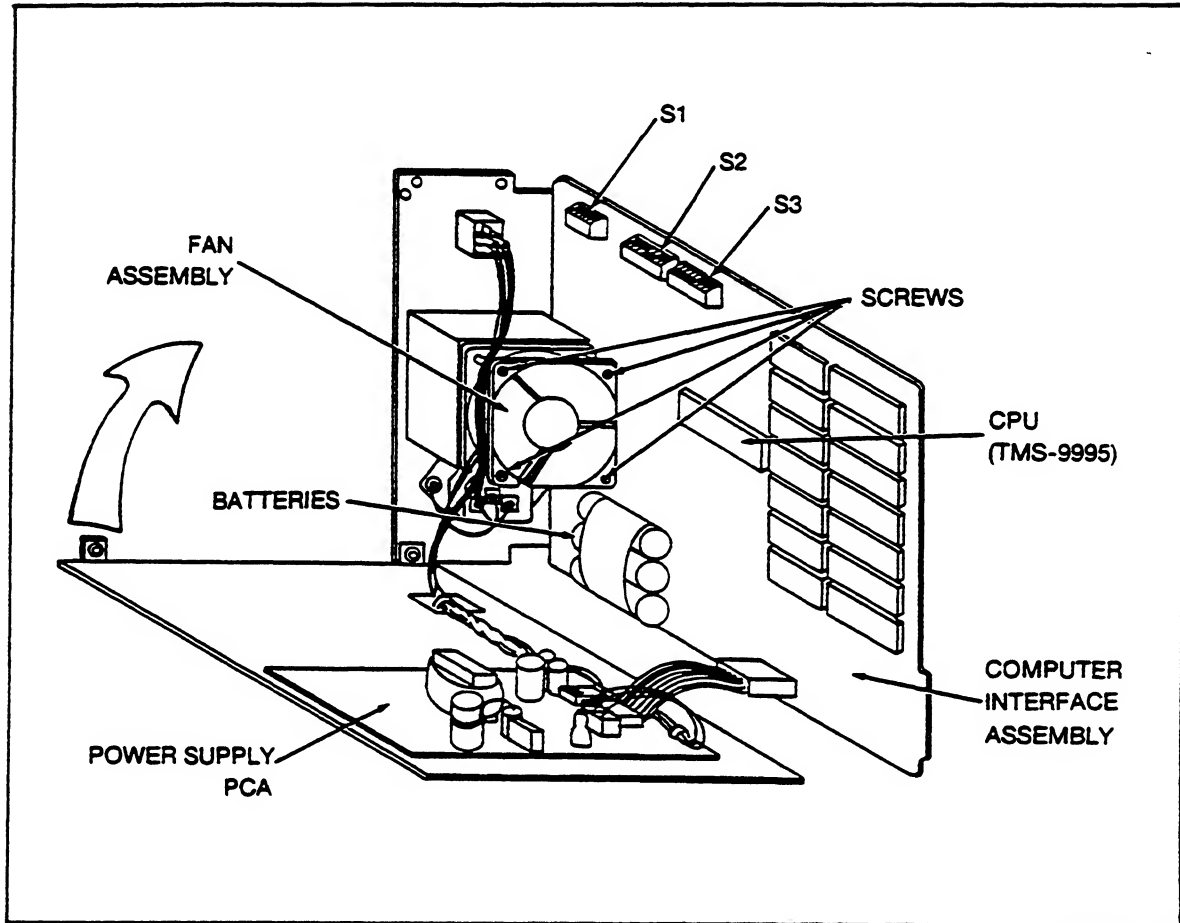
Figure 4-6. Computer Interface Module (Interior)

To access the Power Supply PCA, use the following procedure:

1. Switch OFF power to the Front End and disconnect the ac line cord from the support panel input connector.

2. Remove the four Phillips-head screws (shown in Figure 4-1) that secure the Computer Interface Module to the mainframe chassis.

3. Remove the Computer Interface Module from the chassis by grasping the finger indentation in the fan filter hole (as shown in Figure 4-2) and sliding the module straight back and out.

4. The Power Supply PCA is secured to the right panel of the Computer Interface Module by four Phillips-head screws. To access these screws, first disconnect the right panel from the Computer Interface Module support panel by removing the two securing nuts.

5. Disconnect all leads connecting the power supply to the Computer Interface Assembly, power switch and fan assembly.

6.   To detach the power supply from the right panel, remove four
     Phillips-head screws, one in each corner of the power supply.

Reverse the previous steps to reinstall the Power Supply.

Removing and Reinstalling the Computer Interface Assembly

Refer to Section 9A for Scan/Alarm Option -201 Computer Interface
Assembly removal and installation instructions.

CAUTION

Handle the Computer Interface Assembly with care,
or some semiconductors and ICs can be damaged by
electrostatic discharge during handling. Refer to
the static awareness information at the beginning
of this section for proper handling
precautions.

The Computer Interface Assembly is mounted on the Computer Interface
Module (see Figure 4-6). Use the following procedure to access the
Computer Interface Assembly:

1.   Perform steps 1 through 3 of the Removing and Reinstalling the Power
     Supply procedure (given earlier in Section 4).

2.   Disconnect all leads from the power supply to the Computer
     Interface Assembly.

3.   Place jumper W9, shown in Figure 4-5, in the "batteries
     disconnected" position.

4.   The Computer Interface Assembly is secured to the left panel of the
     Computer Interface Module by four hex-head screws above and below
     the host computer and extender chassis connectors.

     Remove the hex-head screws to detach the Computer Interface
     Assembly from the side panel.

NOTE

The Computer Interface Assembly should be stored
and transported in an anti-static bag.

Reinstall the Computer Interface Assembly by reversing these steps.

Removing and Reinstalling the Fan Assembly

Refer to Section 9A for Scan/Alarm Option -201 fan assembly removal and installation instructions. To remove the fan assembly attached to the standard Computer Interface Assembly, (shown in Figure 4-6), perform the following procedure:

1. Perform steps 1 through 4 of the Removing and Reinstalling the Power Supply procedure (given earlier in Section 4).

2. Disconnect the red and blue leads between the power supply and fan assembly if this has not already been done.

3. To detach the fan assembly (and the fan filter housing) from the front panel of the Computer Interface Module, remove the four screws (shown in Figure 4-6) which secure the fan assembly and filter housing to the panel.

To reinstall the fan assembly reverse the previous steps.

CONTENTS

INTRODUCTION

Section 5 contains performance testing and troubleshooting information for the Helios I Computer Front End mainframe. Performance testing of Front End options is covered in Section 8 (Options -160 through -169), Section 9 (Options -170 through -179), and Section 9A (Option -201).

Mainframe performance testing consists of two procedures: the Mainframe Test and the System Selftest. These tests, which can also serve as initial acceptance tests, verify correct operation of the interface (RS-232-C/RS-422) and interface hardware (ROM, RAM, UART).

The troubleshooting procedures assist service personnel in tracing a malfunction to the printed circuit assembly (pca) level. If a defective pca is identified, we recommend that repair be accomplished using the Fluke Module Exchange Program. For additional information, refer to the Introduction in Section 1.

The mainframe theory of operation (Section 3) and schematics (Section 7) can be used by qualified personnel to troubleshoot the Front End circuit assemblies to the component level. Before troubleshooting to the component level, however, it is advisable to contact a Fluke Service Representative.

PERFORMANCE TESTING

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE INSTRUMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURES.

Mainframe Testing

To verify that the Front End mainframe has been correctly installed and is operating properly, perform the following:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Ensure that communication parameters (i.e., transmission mode, baud rate, parity, number of data bits, number of stop bits) on the Front End and the host (terminal or computer) are properly configured to send and receive serial data.

    This is done by following the instructions under the heading "Setting the Communication Switches" in Section 3A of the Helios I System Manual). If the Computer Interface Assembly was removed to check (or set) the communication parameters, reinstall it at this time.

3. Remove all installed options from the Front End.

4. Directly connect the host (computer or terminal) to the Front End using equipment and cables appropriate to the type of electrical interface (RS-232-C or RS-422).

    Check to make sure connections are tight.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Switch ON power to the host.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

    Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

    MODE=TERM <CR>

    SEND VERSION$ <CR>

The response from the Front End to the host should be:

    Helios-I Version x.y

        or

    Helios Scan/Alarm Version x.y Software by Polar Software Systems

Where x.y is the version number of the installed firmware.

If this response is not returned, a malfunction has occurred.

If "Helios Scan/Alarm Version x.y Software by Polar Software Systems" is returned, perform the additional Alarm Annunciator and Printer Output tests presented in Section 9A.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to respond with its installed version number. One program was written for an IBM* PC and one for a Fluke 1722A Instrument Controller. These programs assume that the Front End has been configured for 9600 baud, no parity, 8 data bits, and 1 stop bit.

---

* IBM is a trademark of International Business Machines Corporation.

NOTE

These programs are examples. If you do not have an
IBM PC or a Fluke 1722A Instrument Controller,
enter a program that will run on your host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    REM request message and read in response
100   PRINT #1,"send version$"
110   LINE INPUT #1,M$
120   PRINT M$
130   END
300   REM wait for message accepted prompt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1%
50    OPEN "KB1:"AS OLD FILE 2%
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   REM request message and read in response
110   PRINT #1,"send version$"
120   INPUT #2,M$
130   PRINT M$
140   END
300   REM wait for message accepted prompt
310   INPUT #2,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

The response from the Front End to the host should be:

      Helios-I Version x.y

        or

Helios Scan/Alarm Version x.y Software by Polar Software Systems

Where x.y is the version number of the installed firmware. If this
response is not returned, a malfunction has occurred.

If "Helios Scan/Alarm Version x.y Software by Polar Software
Systems" is returned, perform the additional Alarm Annunciator and
Printer Output tests presented in Section 9A.

8.   This completes the Mainframe Test.

If the Front End has failed this test, check all connections, then
perform the test again. If the system fails the test a second time,
determine if the interface of the host is functioning properly by
testing it with another system or device. If the host interface is not
at fault, contact your nearest Fluke Service Representative (see
Appendix B).

System SelfTest

The system wide selftest determines if the read only memory (ROM),
random-access memory (RAM), and the serial link universal asynchronous
receiver-transmitter (UART) are operating properly.

1.   Perform the Mainframe Test immediately preceding the System
      Selftest.

2.   Perform a system selftest using PROCEDURE A (Terminal Mode) or
      PROCEDURE B (Computer Mode).

PROCEDURE A. TERMINAL MODE

If Terminal Mode is being used, send the following command to the
Front End:

          MODE=TERM <CR>
          TEST <CR>

If a malfunction is detected, an error message will be returned.

If the Front End passes the selftest routine, the normal Terminal
Mode prompt

          HCLI>

is returned.

PROCEDURE B. COMPUTER MODE

If Computer Mode is being used, modify the program entered in
PROCEDURE B of the Mainframe Test (above) to send the TEST command
to the Front End and read its response. Make this modification by
changing line 100 of the IBM program or line 110 of the 1722A
program to:

          PRINT #1,"test"

3.   Run the modified program.

If a malfunction is detected, the test failure will be reported in the format:

?<error code>

The number, <error code>, will be one of three numbers shown in the table below, which corresponds to one of the messages returned in the Terminal Mode.

ERROR CODE	ERROR MESSAGE	FAULT CONDITION
?20	?ROM failed	First priority failure. A bad ROM or faulty ROM control circuit was detected.
?21	?RAM failed	Second priority failure. A bad RAM or faulty RAM control circuit was detected.
?22	?SL UART failed	Third priority failure. A problem with the serial link UART was detected.

If more than one failure is detected, only the error code or message for the highest priority failure is returned.

NOTE

The Computer Front End will operate after a selftest error has been reported. However, measurements may be unreliable.

4.   The System Selftest is complete.

TROUBLESHOOTING

System Troubleshooting

Troubleshooting a Computer Front End system requires a general understanding of how a system operates. Before troubleshooting, review the system-level block diagram (in Figure 3-1) and the system theory of operation (in Section 3) to familiarize yourself with the interrelationship of the various assemblies that make a Helios I Computer Front End system.

The mainframe theory of operation (Section 3) and schematics (Section 7) can be used by qualified personnel to troubleshoot the Front End pcas to the component level. Before troubleshooting to the component level, however, it is advisable to contact a Fluke Service Representative.

Figure 5-1 provides a system troubleshooting tree. This tree will aid you in troubleshooting a Front End system to the assembly level by isolating a specific, malfunctioning assembly.

Keep the following considerations in mind when using the troubleshooting tree:

o   It is assumed that Helios-to-host communication parameters have been properly set and that external interconnections between them have been properly established.

     Therefore, before starting to troubleshoot, ensure that the communication parameters (i.e., baud rate, number of bits, parity etc.) on the Front End and host are properly configured to send and receive serial data, and that the host transmit and receive signals are connected to the proper pins on the host connecter, J70, of the Front End.

o   The troubleshooting tree covers only the most common sources of system malfunction. It does not cover all possible problems that may occur.

o   The troubleshooting tree isolates only the assembly that is most likely the source of the problem. Other problem sources may exist.

o   The troubleshooting tree can be used with any Front End system configuration and combination of options. Skip over blocks that are not pertinent to your system.

Power Supply Troubleshooting

WARNING

THERE ARE LETHAL VOLTAGES AT VARIOUS POINTS ON THE POWER SUPPLY. EXERCISE EXTREME CAUTION WHEN SERVICING. DISCONNECT THE FRONT END FROM LINE POWER AND DISCHARGE ALL CAPACITORS AS SOON AS THEY ARE ACCESSIBLE.

CAUTION

Running the power supply without a load may damage the power supply. While servicing the power supply, a 0.5A load on 5V should be provided.

Begin troubleshooting the power supply by checking the 250V 2A fast-blow fuse. In most cases, if the fuse is blown, the power supply should be replaced. In rare instances, replacing the fuse will correct the problem.

If the fuse is good, but problems traceable to the power supply are evident, minor adjustments to the power supply may be required. Use the following procedure to adjust the power supply.
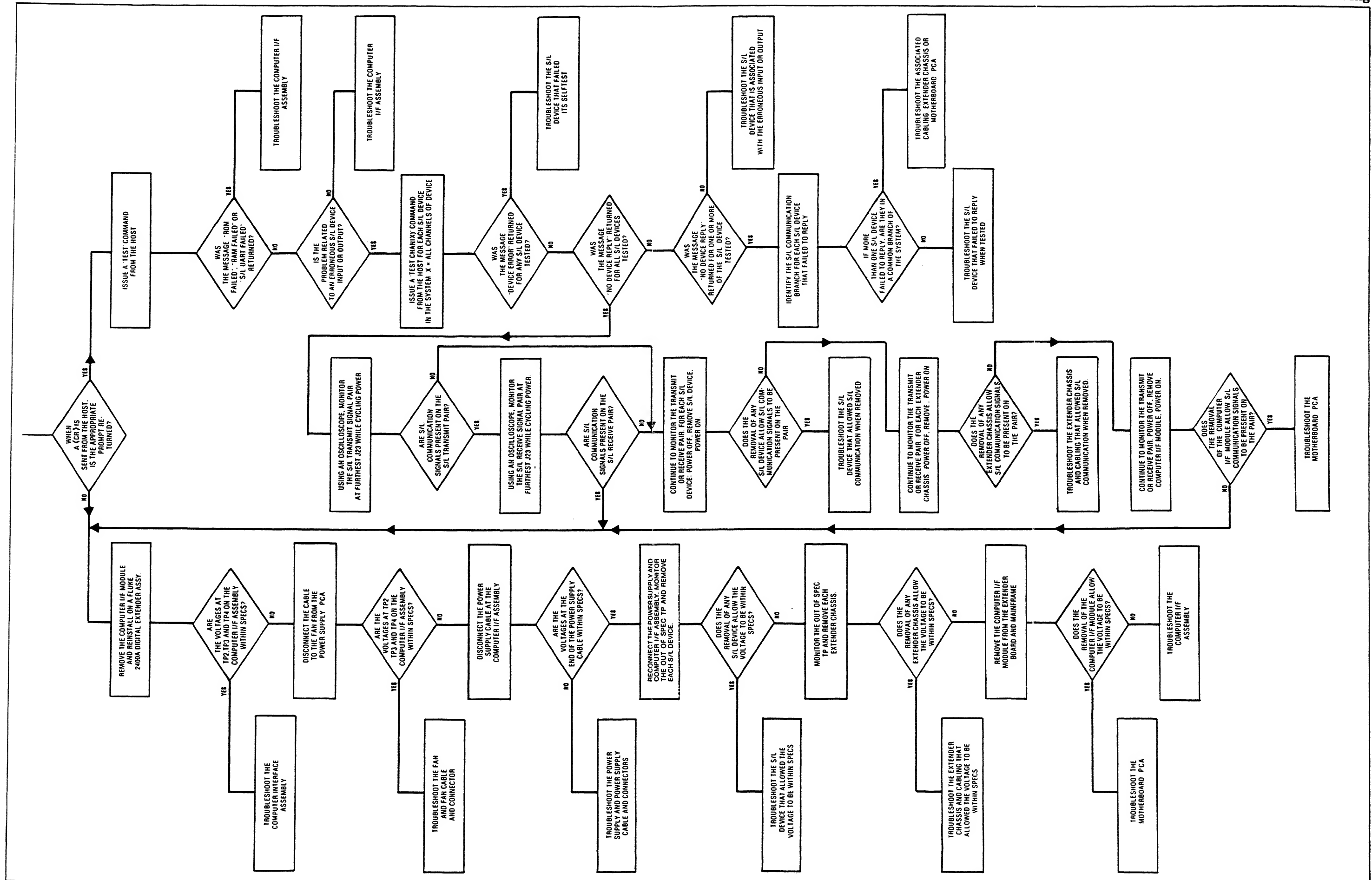
Figure 5-1. System Troubleshooting Tree

POWER SUPPLY ADJUSTMENTS

WARNING

CERTAIN COMPONENTS ON THE POWER SUPPLY HAVE BEEN
SELECTED FOR ELECTRICAL CHARACTERISTICS NOT
SPECIFIED ON THE COMPONENT. THEREFORE, THE POWER
SUPPLY MAY FAIL EVEN IF THESE COMPONENTS ARE
REPLACED WITH COMPONENTS OF THE SAME VALUE AND
TOLERANCES. CONTACT THE POWER SUPPLY MANUFACTURER
FOR THE PROPER COMPONENTS.

NOTE

Use a plastic screwdriver to adjust the power
supply. A metal non-insulated screwdriver may
cause a short if it comes in contact with metal on
the chassis. After adjustment, a penetrating
adhesive, such as Loctite*, should be used to hold
the potentiometer in position.

Make service adjustments to the power supply as follows:

1. Use a DMM to measure the output from the power supply with respect
    to ground.

    If measuring at the power supply, see Table 3-5 for pin locations.

    If measuring at the Computer Interface Assembly see the schematic
    in Section 7 of this manual to locate the test points (TPs).

2. Probe the 5V pin.

    If the output is not within the specified 5.0V to 5.1V range,
    adjust the potentiometer to 5.1V, or adjust for 5.05V at TP4 on the
    Computer Interface Assembly.

3. Probe the +12V and -12V pins.

    If the 5V pin is within specifications, but the 12V pin is not
    within +/-5%, and the -12V pin is not within +/-10% (or the minor
    adjustments do not achieve the desired results), replace the power
    supply or suspect a short circuit in Front End or its option
    assemblies.

    Refer to "Power Supply Access" for instructions on removing and
    installing the power supply.

If it is necessary to troubleshoot the power supply to component level,
refer to the power supply schematic in Section 7.

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* Loctite is a registered trademark of the Loctite Corporation.

CONTENTS

INTRODUCTION

This section contains an illustrated list of replaceable parts for the Helios I Computer Front End mainframe (standard configuration). Refer to Section 9A for a parts list of the Computer Interface Module (A2) used with the Scan/Alarm option. A parts list for each option is included in the approproate subsection of Section 8 (Options -160 through -169) and Section 9 (Options -170 through -179). Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. The parts lists give the following information:

- o Reference designator
- o An indication if the part is subject to damage by static discharge
- o Description
- o Fluke stock number
- o Manufacturers supply code (code-to-name list at the end of this section)
- o Manufacturers part number or generic type
- o Total quantity
- o Any special notes (i.e., factory-selected part)

CAUTION

A * symbol indicates a device that may be
damaged by static discharge.

HOW TO OBTAIN PARTS

Electrical components may be ordered directly from the manufacturer by using the manufacturers part number, or from the John Fluke Mfg. Co., Inc. and its authorized representatives by using the part number under the heading FLUKE STOCK NO. In the U.S., order directly from the Fluke Parts Dept. by calling 1-800-526-4731. Parts price information is available from the John Fluke Mfg. Co., Inc. or its representatives. Prices are also available in a Fluke Replacement Parts Catalog which is available on request.

In the event that the part ordered has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

To ensure prompt delivery of the correct part, include the following information when you place an order:

- o Instrument model and serial number
- o Part number and revision level of the pca containing the part.
- o Reference designator
- o Fluke stock number
- o Description (as given under the DESCRIPTION heading)
- o Quantity

MANUAL STATUS INFORMATION

The Manual Status Information table in Section 10 defines the assembly

revision levels that are documented in the manual. Revision levels are printed on the component side of each pca.

NEWER INSTRUMENTS

Changes and improvements made to the instrument are identified by incrementing the revision letter marked on the affected pca. These changes are documented on a supplemental change/errata sheet which, when applicable, is included with the manual.

SERVICE CENTERS

A list of service centers is located in Section 10.

NOTE

> This instrument may contain a Nickel-Cadmium battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke service center for recycling information.

Table 6-1. Helios I Final Assembly
(See Figure 6-1.)

REFERENCE DESIGNATOR -A>-NUMERICS---->		S--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	N O T -E-
A	1	MOTHERBOARD PCA	799163	89536	799163	1	
A	2	* COMPUTER I/F PCA	793562	89536	793562	1	
BT	1	POWER SUP,40W,+5@3.5A,+12@2A,-12@1A	769406	61852	XL40-3621	1	
DS	1	LED,GREEN,PANEL MT WITH WIRE LEADS	723809	91802	5100B10	1	
E	1	STRAP,GROUNDING	578989	89536	578989	1	
H	1	FILTER,AIR	793596	89536	793596	1	
H	2	CONN ACC,D-SUB,JACK SCREW,4-40	448092	0RYZ9	D-20418-2	6	
H	3	SCREW,PH,P,LOCK,STL,6-32,.375	152165	74594	152165	4	
H	4	SCREW,RH,SL,LOCK,STL,6-32,2.250	114421	89536	114421	4	
H	5	WASHER,LOCK,SPLIT,STL,.141,.266,.031	110692	86928	5850-13-22	4	
H	6	WASHER,LOCK,INTRNL,STL,.123ID	110403	73734	1302	2	
H	7	WASHER,FLAT,BR,.119,.281,.025	110775	86928	5714-23-25-N	2	
H	8	NUT,HEX,MINI,SS,6-32	110569	73734	70206	4	
H	9	NUT,HEX,STL,4-40	110635		COMMERCIAL	2	
H	10	SCREW,PH,P,SEMS,STL,6-32,.375	177022		COMMERCIAL	10	
H	11	SCREW,FH,P,STL,8-32,.625	875831		COMMERCIAL	6	
H	12	SCREW,PH,P,SEMS,STL,6-32,.500	177030		COMMERCIAL	4	
H	13	SCREW,FH,P,STL,8-32,.875	650119		COMMERCIAL	4	
H	14	SCREW,PH,P,LOCK,STL,6-32,.750	114223	74594	114223	12	
H	15	SCREW,FH,P,STL,8-32,.750	876391		COMMERCIAL	6	
H	16	SCREW,FH,P,STL,6-32,.375	837682		COMMERCIAL	2	
H	17	NUT,SPRING,FLAT,STEEL,6-32	832345		COMMERCIAL	12	
H	18	SCREW,PH,P,SEMS,STL,6-32,.750	309963		COMMERCIAL	8	
J	80	PWR PLUG PART,HOUSING	474668	27264	15-04-0703	1	
MP	1	PANEL, REAR	787424	89536	787424	1	
MP	2	SHIELD, CARD GUIDE	793448	89536	793448	1	
MP	3	SHROUD, FAN	793570	89536	793570	1	
MP	4	RETAINER, FILTER	793588	89536	793588	1	
MP	5	LABEL COPYRIGHT	846365	89536	846365	5	
MP	6	SPACER,.250 RND,AL,.156ID,.750	100966	55566	11328A7	4	
MP	7	CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	4	
MP	8	DECAL, NAMEPLATE	922674	89536	922674	1	
MP	9	OPTION COVER MODIFIED	633255	89536	633255	3	
MP	10	NAMEPLATE, SERIAL -REAR PANEL-	472795	89536	472795	1	
MP	11	DECAL,2289A REAR BEZEL (USA)	794693	89536	794693	1	
MP	13	FRONT BEZEL, PAINTED	660878	89536	660878	1	
MP	14	GRILL, FRONT PANEL	793604	89536	793604	1	
MP	15	GASKET, REAR	712067	89536	712067	1	
MP	16	FRONT PANEL	864657	89536	864657	1	
MP	17	COVER, TOP	712232	89536	712232	1	
MP	18	COVER, BOTTOM	716043	89536	716043	1	
MP	19	BRACKET,CARD GUIDE	578948	89536	578948	1	
MP	20	HANDLE,STRAP	646851	89536	646851	2	
MP	21	HANDLE RETAINER	579052	89536	579052	4	
MP	22	BRACKET,HANDLE SUPPORT	632414	89536	632414	4	
MP	23	HANDLE,SIDE MODIFIED	646638	89536	646638	2	
MP	24	CHASSIS SIDE MODIFIED	581942	89536	581942	2	
MP	25	CHASSIS BASE MODIFIED	581959	89536	581959	2	
MP	26	TAPE,FOIL,ALUM,CONDUCT,1/2"WIDE	696583	28213	1170	1	
MP	27	FOOT, SINGLE BAIL TYPE (DARK UMBER)	653923	89536	653923	4	
MP	28	REAR BEZEL,FINISHED	749812	89536	749812	1	
MP	29	DECAL,CORNER	605691	89536	605691	2	
MP	30	DECAL, FLUKE-PHILIPS, WHITE,SMALL	835280	89536	835280	1	
MP	31	CLAMP,U-TYPE,STL,.090	782896	78553	C25612-014-4	4	
S	1	SWITCH,ROCKER,DPST,6A	615054	55224	JWA2120-0012	1	
TM	1	HELIOS I COMPUTER FRONT END SYS MAN	834366	89536	834366	1	
TM	2	HELIOS 1 COMPUTER FRONT END SER MAN	834382	89536	834382	0	
W	1	CABLE, POWER SUPPLY	793612	89536	793612	1	
W	3	ASSY, FAN, CABLE & CONNECTOR	794636	89536	794636	1	
W	4	HARNESS,COMPUTER I/F MODULE	873182	89536	873182	1	
W	7, 9- 12	JUMPER,REC,2 POS,.100CTR,.025 SQ POST	530253	00779	530153-2	5	
W	8	CORD,LINE,5-15/IEC,3-18AWG,SVT,7.5 FT	284174	70903	17239	1	

An * in 'S' column indicates a static-sensitive part.

NOTES:

A Recommended Spare Parts Kit (Fluke PN 798629) is available. This kit
contains spare parts to maintain 1 to 2 Front End mainframes for 5 years or
3 to 5 mainframes for 3 years. Spare parts for any installed options must be
ordered separately.
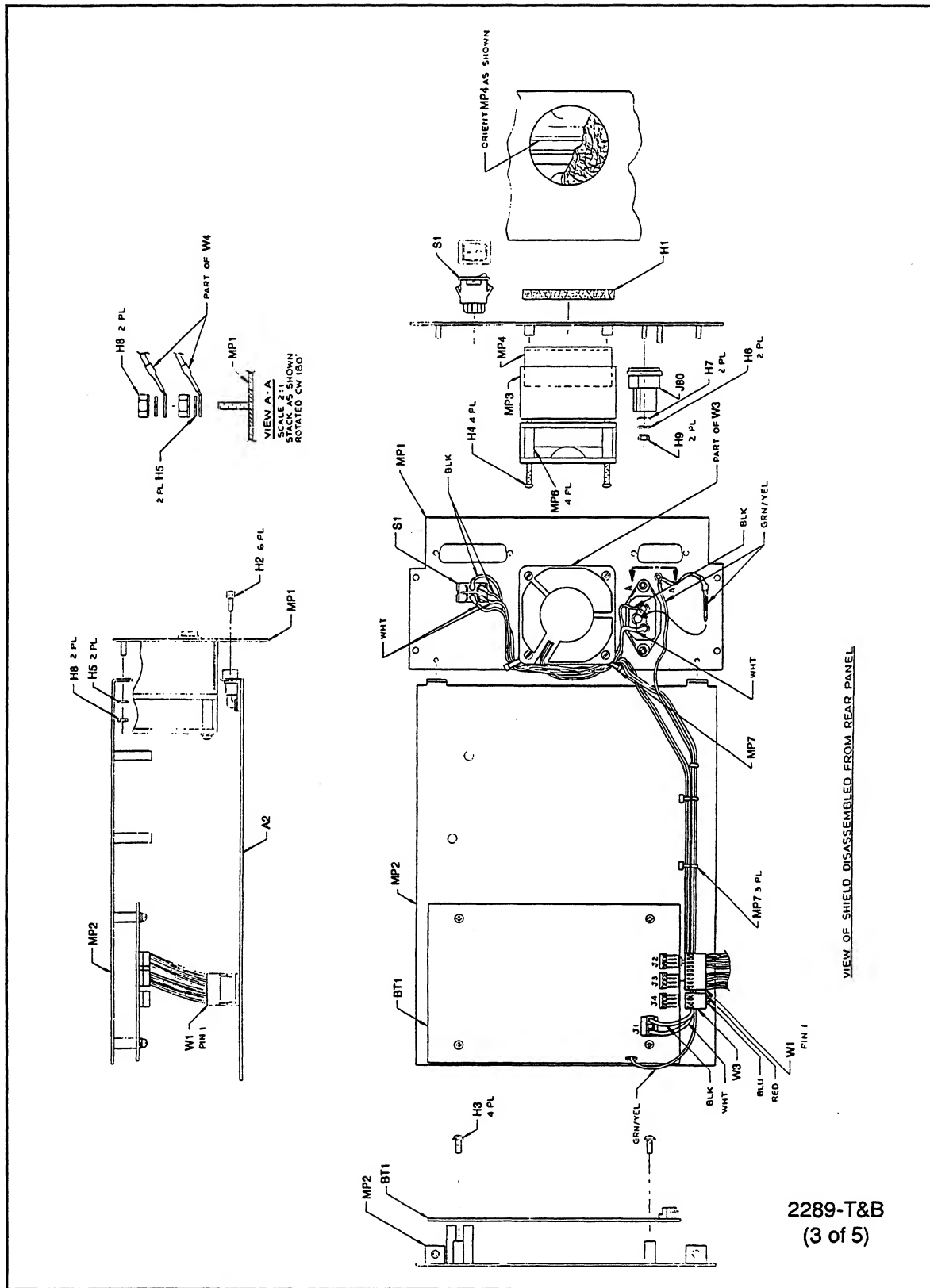
Figure 6-1. Helios I Final Assembly
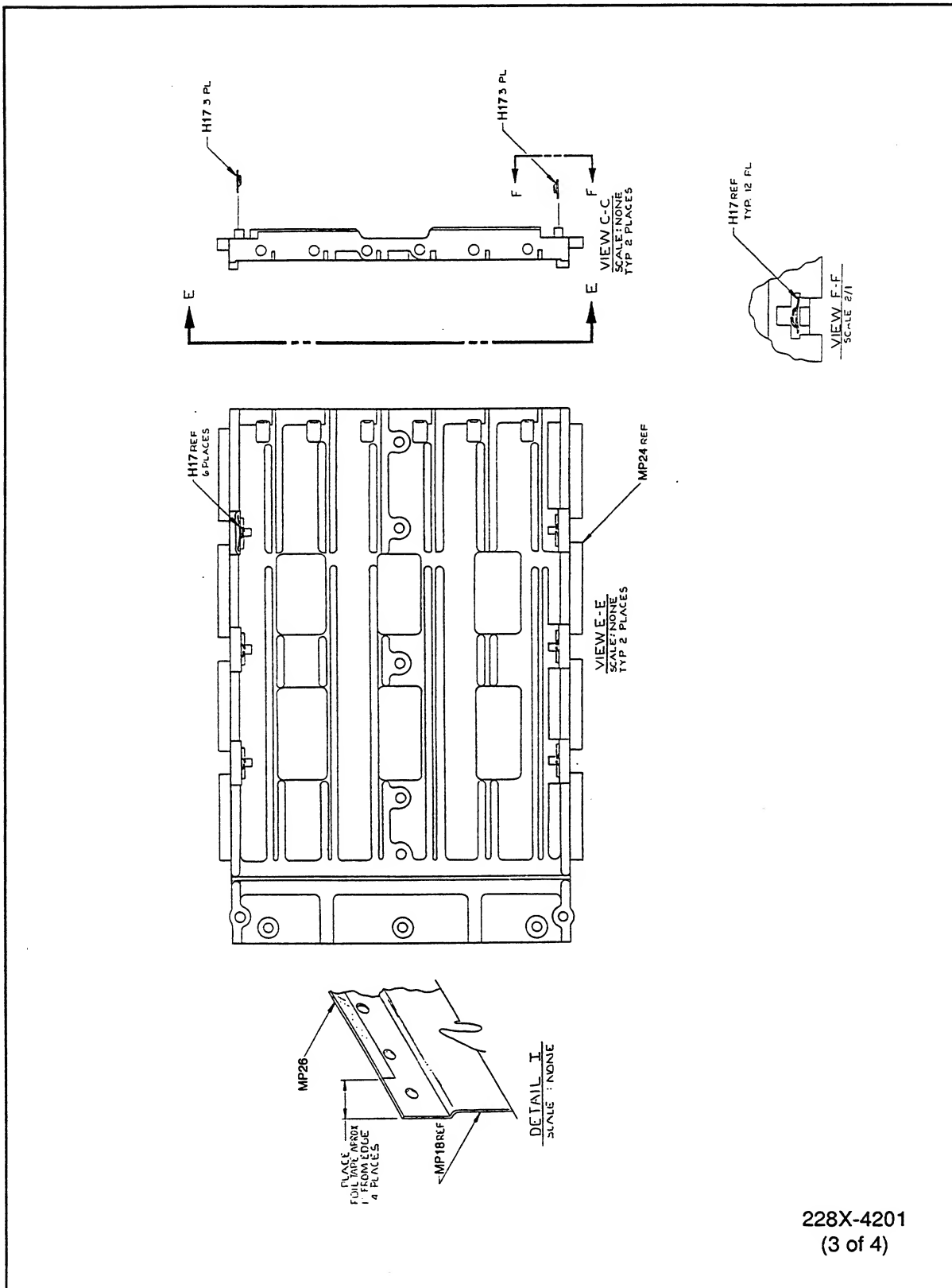
228X-4201
(3 of 4)

Figure 6-1. Helios I Final Assembly (cont)

228X-4201
(2 of 4)

Figure 6-1. Helios I Final Assembly (cont)

MP29

MP8

MP28

MP9

H10

MP10

MP11

H10 4 PL

2289A-T&B
(4 of 5)
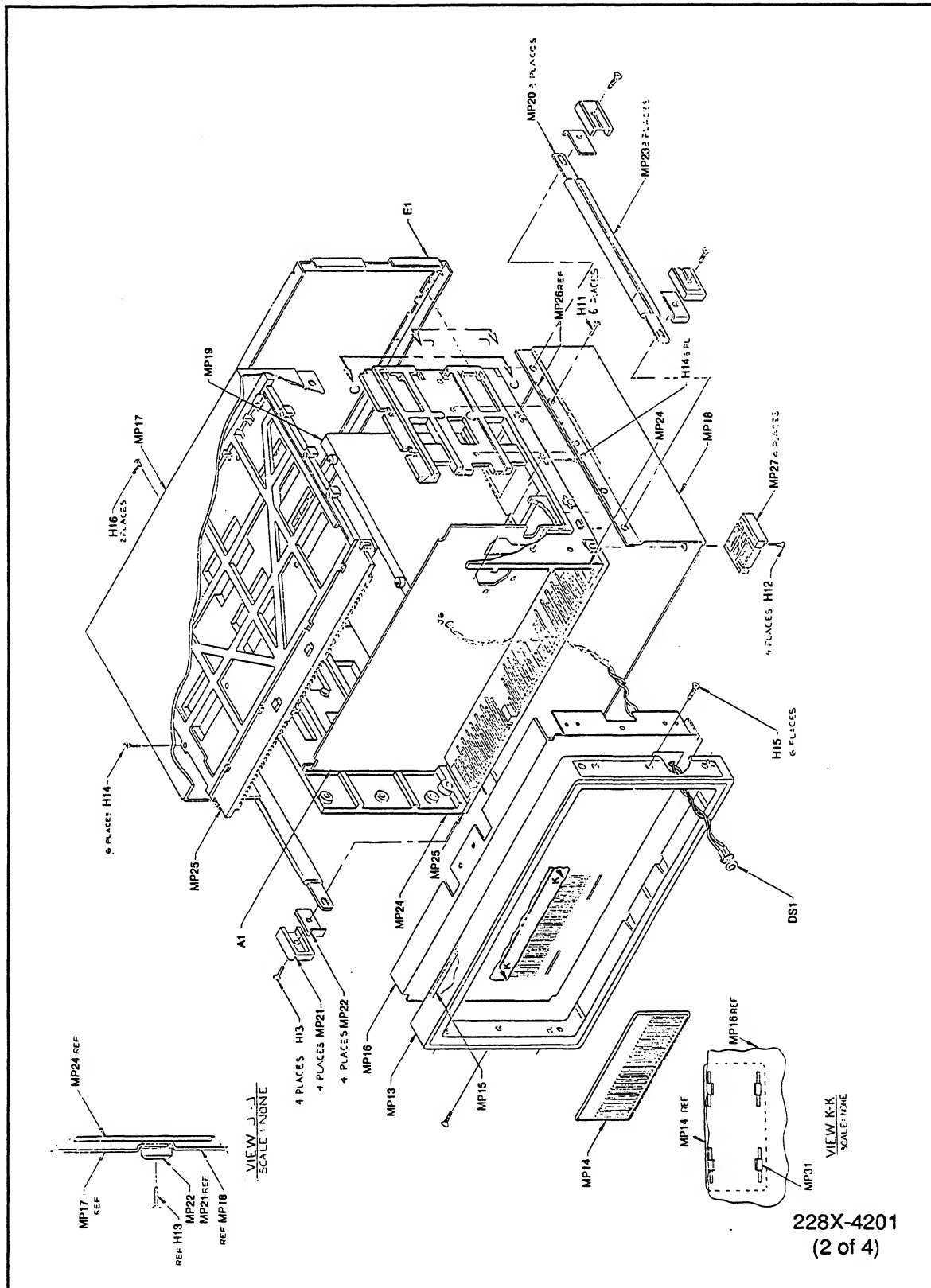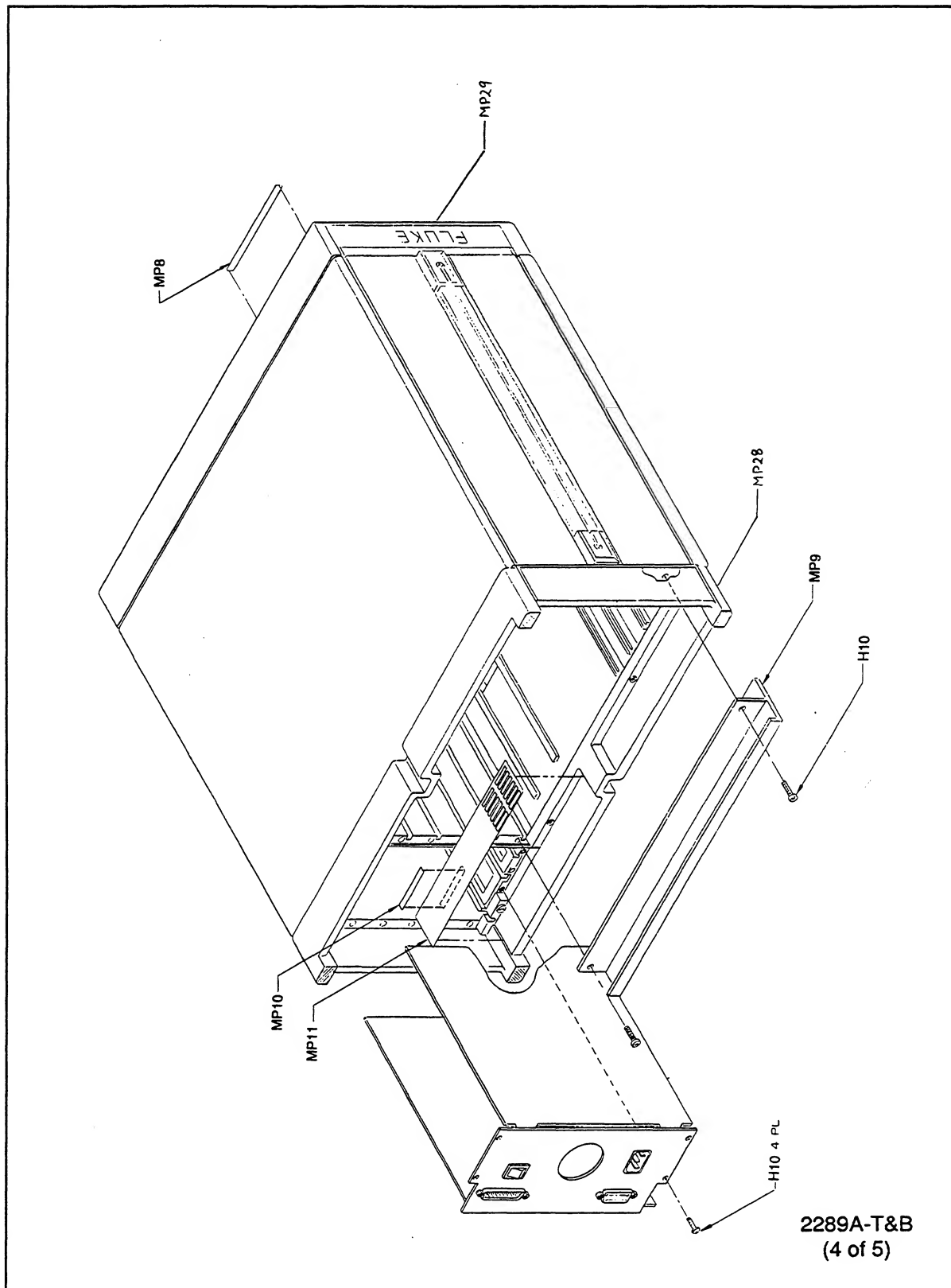
Figure 6-1. Helios I Final Assembly (cont)

Table 6-2. A1 Motherboard PCA
(See Figure 6-2.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	-------------DESCRIPTION-------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	N O T -E-
H 1		SCREW,RH,SL,NYL,6-32,.625	330019	89536	330019	4	
H 2		NUT,HEX,NYL,6-32	111013	89536	111013	4	
H 3		SPACER,.250 RND,AL,.156ID,.250	153155	55566	11248A7	4	
J 1		CONN,PWB EDGE,REC,.100CTR,72 POS	520155	00779	1-530843-9	1	
J 2		CONN,PWB EDGE,REC,.100CTR,20 POS	520189	00779	4-530843-9	1	
J 12		CONN,PWB EDGE,REC,.100CTR,44 POS	520148	00779	1-530843-5	1	
MP 1		DECAL,PART NUMBER	648758	89536	648758	1	
MP 2	*	INSULATOR,MOTHERBOARD	580084	89536	580084	1	
R 1		RES,CF,120,+-5%,0.25W	442293	59124	CF1/4 121J	1	
VR 1	*	IC,VOLT REG,ADJ,1.2 TO 32 V,0.1 A	810242	01295	TL317CLP	1	

An * in 'S' column indicates a static-sensitive part.

2281A-1601
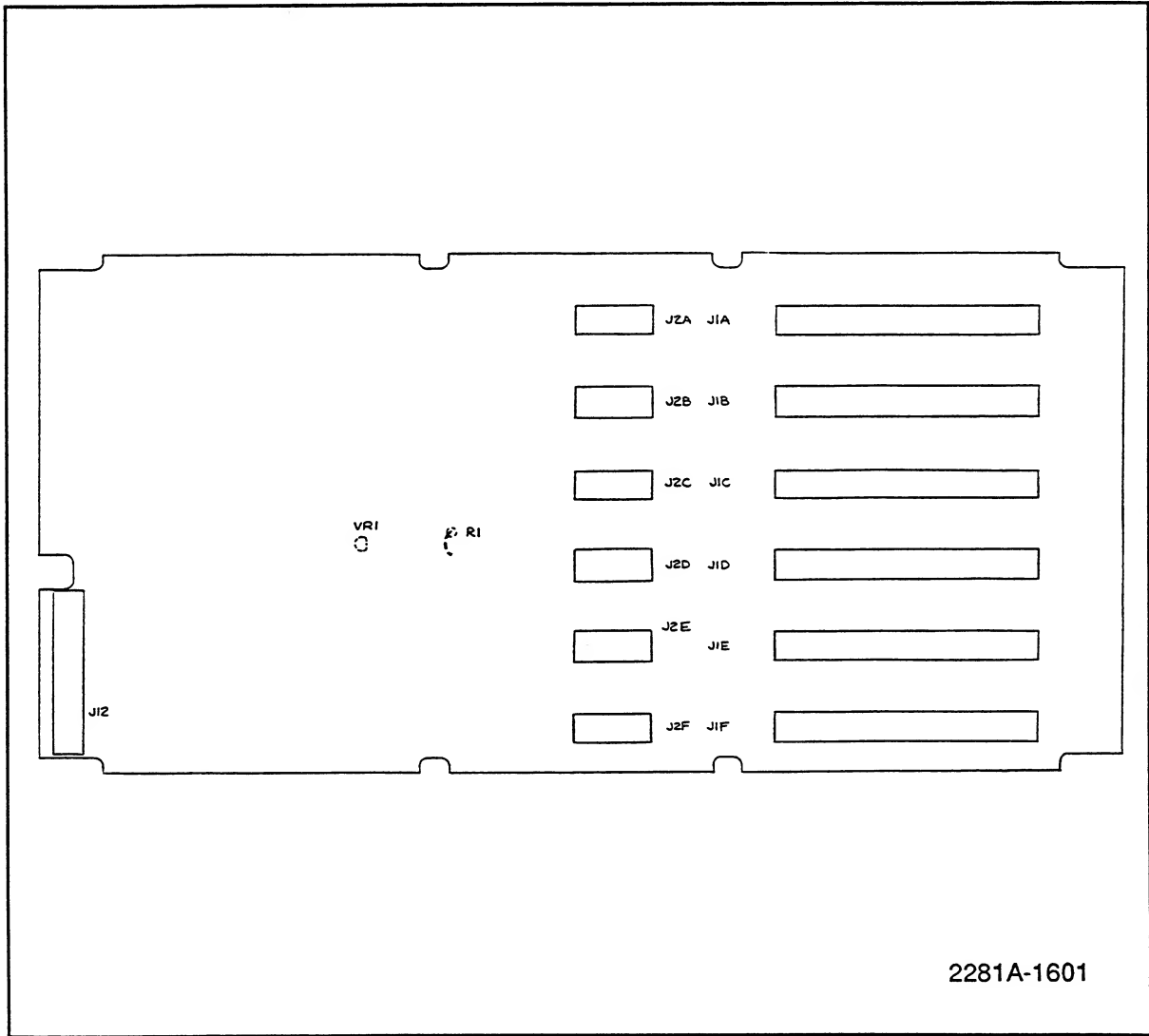
Figure 6-2. A1 Motherboard PCA

Table 6-3. A2 Computer Interface PCA
(See Figure 6-3.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	-------------DESCRIPTION-------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	N O T -E-
BT 1		BATTERY,NI-CAD,3.6V,0.45AH	615476	57053	41B020AD01501	1	
C 2, 3, 5-		CAP,CER,330PF,+-5%,100V,COG	528620	04222	SR151A331JAA	8	
C 8, 10, 11			528620				
C 9, 17, 20-		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	04222	SR205E224MAA	34	
C 39, 41- 52			519157				
C 14		CAP,CER,0.01UF,+-20%,100V,X7R	407361	04222	SR201C103MAA	1	
C 15		CAP,CER,10PF,+-5%,100V,COG	566042	04222	SR151A100JAA	1	
C 16		CAP,CER,39PF,+-2%,100V,COG	512962	04222	SR151A390GAA	1	
C 18, 19		CAP,CER,18PF,+-2%,100V,COG	512335	51406	RPE110A184G1	2	
C 40		CAP,AL,1000UF,+-20%,16V,SOLV PROOF	837468	62643	KME16VB102M10X20MX	1	
C 53		CAP,CER,1000PF,+-5%,50V,COG	528539	04222	SR215A102JAA	1	
CR 1- 3	*	DIODE,SI,SCHOTTKY BARRIER,SMALL SIGNL	523738	28480	5082-2835	3	
CR 4- 11		DIODE,SI,50 PIV,1.0 AMP	379412	04713	1N4933	8	
H 1		WASHER,FLAT,BR,.119,.281,.025	110775	86928	5714-23-25-N	4	
H 2		WASHER,LOCK,SPLIT,STL,.115,.223,.025	110395	86928	5850-11-Z2	4	
H 3		NUT,HEX,STL,4-40	184044	89536	184044	4	
J 23		CONN,D-SUB,PWB,RT ANG,15 SCKT	707034	00779	747021-5	1	
J 70		CONN,D-SUB,PWB,RT ANG,25 PIN	706218	00779	747022-5	1	
J 74		HEADER,1 ROW,.100CTR,6 PIN	478669	00779	103747-6	1	
J 75		HEADER,1 ROW,.100CTR,8 PIN	800169	00779	640456-8	1	
MP 1		STUD,BROACH,PH BRNZ,4-40,.375	603894	46384	KFH-440-6	4	
MP 2		CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	1	
MP 3		CABLE TIE,8"L,0.091"W,2.0 DIA	331157	06383	PLT2M	2	
MP 5		SHUNT BAR,PWB,3 INCH	453613	28213	5020	1	
R 1		RES,CF,100,+-5%,0.25W	348771	59124	CF1/4 101J	1	
R 2, 3, 20,		RES,CF,33,+-5%,0.25W	414524	59124	CF1/4 330J	4	
R 21			414524				
R 4- 7, 16-		RES,CF,51,+-5%,0.25W	414540	59124	CF1/4 510J	8	
R 19			414540				
R 8, 11		RES,CF,5.1K,+-5%,0.25W	368712	59124	CF1/4 512J	2	
R 9, 10, 13,		RES,CF,270,+-5%,0.25W	348789	59124	CF1/4 271J	4	
R 15			348789				
R 12, 14		RES,CF,47K,+-5%,0.25W	348896	59124	CF1/4 473J	2	
R 22, 23, 30-		RES,CF,10K,+-5%,0.25W	348839	59124	CF1/4 102J	7	
R 33, 35			348839				
R 24		RES,MF,107K,+-1%,0.125W,100PPM	288399	91637	CMF-55 1073F T-1	1	
R 25		RES,CF,1K,+-5%,0.25W	343426	59124	CF1/4 102J	1	
R 26		RES,MF,37.01K,+-0.1%,0.125W,50PPM	386425	91637	CMF-55 37011B T-2	1	
R 27		RES,CF,180K,+-5%,0.25W	348946	59124	CF1/4 184J	1	
R 28, 37		RES,CF,100K,+-5%,0.25W	348920	59124	CF1/4 104J	2	
R 34		RES,CC,2.2K,+-5%,0.5W	108506	01121	EB2225	1	
R 36, 38		RES,CF,2M,+-5%,0.25W	442582	59124	CF1/4 205J	2	
S 1		SWITCH,DIP,DPST,PIANO,6 POS	800037	00779	1-435802-7	1	
S 2, 3		SWITCH,DIP,SPST,PIANO,SEALED,8 POS	658567	00779	435802-9	2	
TP 1- 4		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	4	
U 1, 7	*	IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	27014	DS1692J	2	
U 3	*	IC,LSTTL,QUAD RS422 LINE RCVR,3-STATE	525303	27014	DS3486N	1	
U 4, 6	*	IC,TTL,QUAD RS232C LINE RECEIVER	524850	27014	DS1489AN	2	
U 5	*	IC,TTL,QUAD RS232C LINE DRIVER	414052	27014	DS1488N	1	
U 8	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	1	
U 9	*	IC,LSTTL,TRIPLE 3 INPUT AND GATE	393082	27014	DM74LS11N	1	
U 11, 14	*	IC,NMOS,ASYNC COMMUNICATION CONTROLLR	483552	01295	TMS9902ANL-40	2	
U 15, 17, 23	*	IC,LSTTL,8-1 MUX W/3-STATE OUTPUTS	407577	27014	DM74LS251N	3	
U 16	*	IC,COMPARATOR,DUAL,LO-POWER,8 PIN DIP	783662	01295	TLC372CP	1	
U 18, 26	*	IC,LSTTL,8BIT ADDRSABLE LATCH,W/CLR	419242	6E570	74LS259N	2	
U 19	*	IC,CMOS,SERIAL I/O CALENDER & CLOCK	586412	33297	uPD4990AC	1	
U 20	*	IC,NMOS,16 BIT MICROCOMPUTER	640417	01295	MP9572N	1	
U 21, 29, 31	*	IC,LSTTL,OCTL LINE DRVR W/3-STATE OUT	429035	01295	SN74LS244N	3	
U 22, 25, 28,	*	IC,LSTTL,3-8 LINE DCDR W/ENABLE	407585	27014	DM74LS138N	4	
U 32	*		407585				
U 24, 27	*	IC,CMOS,3-8 LINE DCDR W/ENABLE	773036	01295	SN74HC138N	2	
U 30	*	IC,LSTTL,OCTL BUS TRNSCVR W/3-ST OUT	477406	01295	SN74LS245N	1	
U 35- 38, 40-	*	IC,CMOS,8KX8 STAT RAM,120 NSEC	754259	44648	KM6264BLP-10	9	
U 43, 47	*		754259				
U 44- 46, 48,		IC,NMOS, 8K X 8 EPROM	723569	61394	DQ2764-2	5	
U 49			723569				
VR 1	*	ZENER,TRANS SUPPRESSOR,6V	508655	11961	1N5908	1	
VR 2	*	IC, 1.23V,150 PPM T.C.,BANDGAP V. REF	634451	27014	LM385Z-1.2D26Z	1	
XU 20		SOCKET,IC,40 PIN	429282	00779	2-640379-1	1	
XU 34- 49		SOCKET,IC,28 PIN	448217	95146	228AG-39D	16	
Y 1		CRYSTAL,11.9808MHZ,+-0.01%,HC-18/U	642777	61429	HC-18/U-11.9808MHZ	1	
Y 2		CRYSTAL,32.768KHZ,+-0.003%	501817	87516	861-T-32.768	1	
Z 1, 2		RES,CERM,SIP,10 PIN,9 RES,47K,+-2%	485193	91637	CSC10A-01-473G	2	
Z 4		RES,CERM,SIP,10 PIN,9 RES,4.7K,+-2%	484063	91637	CSC10A-01-472G	1	
Z 5		RES,CERM,SIP,8 PIN,7 RES,47K,+-2%	413286	91637	CSC08A-01-473G	1	
Z 6		RES,CERM,SIP,6 PIN,5 RES,4.7K,+-2%	494690	91637	CSC06A-01-472G	1	

An * in 'S' column indicates a static-sensitive part.

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Figure 6-3. A2 Computer Interface PCA

CONTENTS

NOTES

CONTENTS

DESCRIPTION

The -160 AC Volts Input Connector (shown in Figure 160-1) mates with the Thermocouple/DC Volts Scanner and converts ac input voltages to dc for input to the scanner.

Ten ac-voltage input and ten dc-voltage input channels are provided on the connector. The input connector mates with the Thermocouple/DC Volts Scanner through a card-edge connector. The entire assembly is enclosed in a plastic housing that provides strain relief for the external wiring to the connector terminals.

Two screw terminals labeled HI and LO are provided for each channel. Channels 0 through 9 are ac voltage input channels and channels 10 through 19 are dc voltage input channels. Channels 0 through 9 accept and convert ac voltages between 5V ac rms and 250V ac rms to dc voltages to be read by the Front End using the -161 High Performance A/D Converter and the -162 Thermocouple/DC Volts Scanner. Channels 10 through 19 can be used to measure dc voltages to 64V.

The LO input terminal and a shield are connected together within the assembly so that system guard and the LO input are at the same potential. This helps minimize common mode voltage errors in the measurement.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: AC Voltage Input Connector theory of operation, performance tests, a parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are in the Helios I System Manual. Option specifications are located in the appendices to this manual and in the System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 160-1. Table 2-2 in Section 2 of this manual lists the test equipment required for all procedures in this manual.
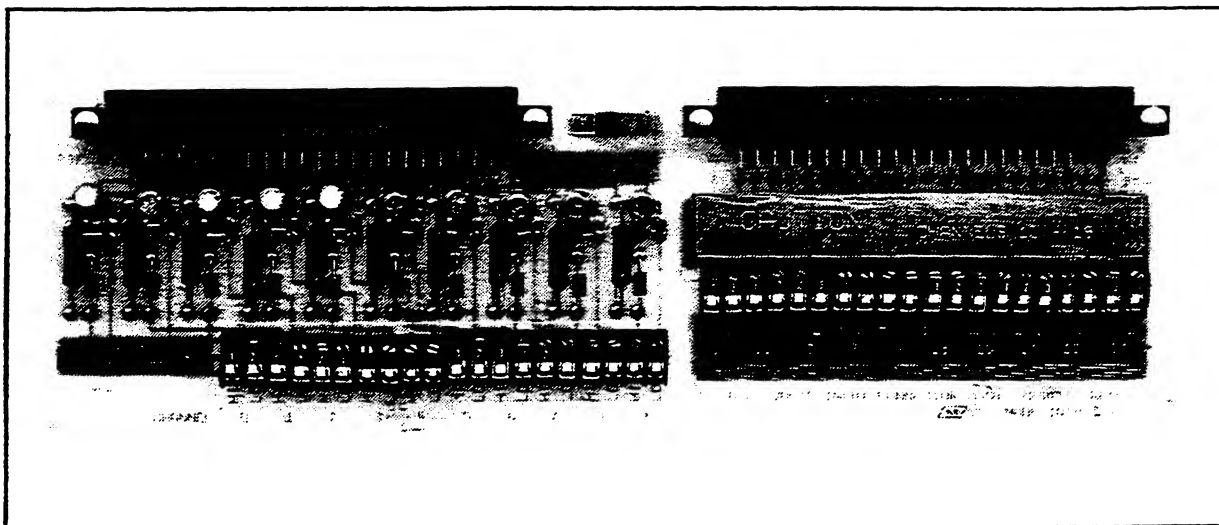
Figure 160-1. AC Voltage Input Connector

Table 160-1. Required Test Equipment for -160

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
AC Voltage Source	10.0V +/- 0.01V	Fluke 5100B
DC Voltage Source	6.2V +/- 155 uV	Fluke 343
Thermocouple/DC Volts Scanner	NA	Fluke Option -162 (no substitute)
High Performance A/D Converter	NA	Fluke Option -161 (no substitute)

THEORY OF OPERATION

The theory of operation for the AC Voltage Input Connector begins with a functional description, followed by a detailed circuit analysis. A schematic diagram of the AC Voltage Input Connector is at the end of this subsection.

Overall Functional Description

The ac-to-dc conversion circuitry for channels 0 through 9 consists of a half-wave rectifier, voltage divider, and a low-pass filter for each

of the ten channels. The converter is average responding and calibrated to indicate the rms value of a sine wave. The conversion process converts a sinusoidal ac voltage to its rms value, minus 0.32 volts, divided by 1000.

Detailed Circuit Description

The following description uses the component designations for channel 0 although it applies to all channels. Only the component designations change from channel to channe.. Diode CR1 rectifies the ac voltage to be measured. This voltage is the divided and filtered by a network consisting of R1, R11, R21, a..d C1. The dc output voltage equals the rms value of a sinusoidal input from 45 Hz to 450 Hz, minus 0.32V, divided by 1000. Overall ripple rejection is from the combination of this low-pass filter and the input filter on the -161 High Performance A/D Converter.

GENERAL MAINTENANCE

The AC Voltage Input Connector normally requires no cleaning unless dirt, dust, or other contamination is visible on the surface. Cleaning instructions are found in Section 4 of this manual.

PERFORMANCE TESTS

The following test verifies that the AC VOLTAGE INPUT CONNECTOR is fully functional and within specifications. This procedure can be used as an initial acceptance test or as a troubleshooting aid.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the -161 A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the -162 Thermocouple/DC Volts Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on the AC Volt Input Connector. Install the connector on the scanner.

4. Reconnect the Front End's ac line cord, and switch the power ON.

5. Connect the AC calibrator output to the HI and LO test leads of the AC Voltage Input Connector installed on the scanner.

6. Set the calibrator output to 10.00V, 60 Hz.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

    MODE=TERM <CR>

    DEF CHAN(0..9)=AVIN <CR>

    FORMAT=DECIMAL <CR>

    SEND CHAN(0) <CR>

The value returned for the selected channel should be 10.00V +/- 0.2V (1.00000E+01).

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs will cause the Front End to take an ac voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

   The following programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for an IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
100   GOSUB 300
110   PRINT #1,"def chan(0..9)=avin"
120   GOSUB 300
```

```
130   PRINT #1,"format=decimal"
140   GOSUB 300
150   REM make measurement and read in response
160   PRINT #1,"send chan(0..9)"
170   FOR I=0 TO 9
180   INPUT #1,M$
190   PRINT "chan";I;"=";
200   PRINT USING "###.##";VAL(M$);
210   PRINT " Volts AC"
220   NEXT I
230   END
300   REM wait for message accepted prompt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for a 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1
50    OPEN "KB1:"AS OLD FILE 2
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"count=off"
110   GOSUB 300
120   PRINT #1,"def chan(0..9)=avin"
130   GOSUB 300
140   PRINT #1,"format=decimal"
150   GOSUB 300
160   REM make measurement and read in response
170   PRINT #1,"send chan(0..9)"
180   FOR I=0 TO 9
190   INPUT #2,M$
200   PRINT "chan";I;"=";
210   PRINT USING "S###.##",VAL(M$);
220   PRINT " Volts AC"
230   NEXT I
240   END
300   REM wait for message accepted prompt
310   INPUT #2,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

The value returned for the selected channel should be 10.00V +/-
0.2V. Ignore readings for the unselected channels.

8.   Set the calibrator output to 0. Move the AC Voltage Input Connector
     test leads to the terminals for the next channel to be tested.

9. Repeat steps 6 through 8 for each remaining ac input channel (1 through 9), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

10. The ac portion of the AC Voltage Input Connector performance test is complete.

11. To test the dc voltage input channels (channels 10 through 19), perform the 176 Voltage Input Connector performance test provided in Section 9.

CALIBRATION

The AC Voltage Input Connector requires no calibration.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the AC Voltage Input Connector is given in Table 160-2. For parts ordering information, see Section 6 of this manual.

Figure 160-2 is schematic diagram of the -160 AC Voltage Input Connector.

TABLE 160-2 AC VOLTAGE INPUT CONNECTOR
(SEE FIGURE 160-2.)

REFERENCE DESIGNATOR A->NUMERICS--->		S -------DESCRIPTION------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C	1- 10	CAP,AL,47UF,+-20%,10V	613984	89536	613984	10		
CR	1- 10	• DIODE,SI, 1K PIV, 1.0 AMP	453399	04713	1N4007	10		
H	1	STEEL,CAD,PLATED,.125X .500	276493	89536	276493	4		
H	2	WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4		
MP	1	CONNECTOR HOUSING, TOP	578971	89536	578971	1		
MP	2	CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1		
MP	3	DECAL,AC VOLTAGE INPUT CONNECTOR	722975	89536	722975	1		
MP	4	DECAL, OPTION -160	722983	89536	722983	1		
P	36, 37	CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2		
R	1- 10	RES,MF,1M,+-0.1%,0.5W,25PPM	266114	89536	266114	10		
R	11- 20	RES,MF,150K,+-1%,0.125W,25PPM	257444	89536	257444	10		
R	21- 30	RES,MF,2.26K,+-0.1%,0.125W,25PPM	501320	89536	501320	10		
TB	1	TERM STRIP,PWB,ANGL ENTRY,10 CONTACTS	501403	89536	501403	4	2	

MP3

MP1

MP4

MP2
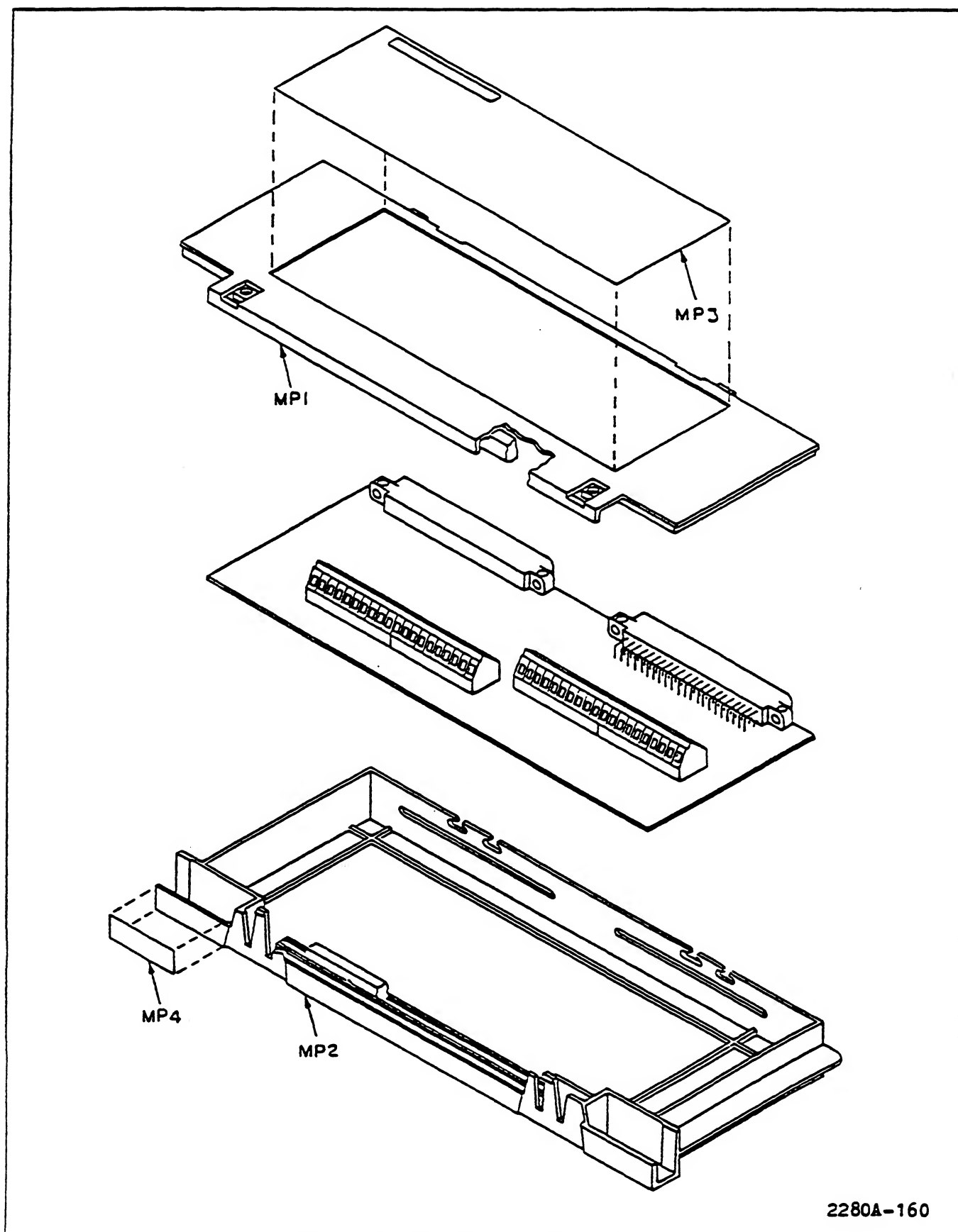
2280A-160

Figure 160-2. -160 AC Voltage Input Connector

DESCRIPTION

The -161 High Performance A/D Converter (shown in Figure 161-1), is an analog-to-digital converter for measuring scanner input voltages. These dc voltages can represent a variety of phenomena, depending on the input connector and scanner options installed with the A/D Converter.
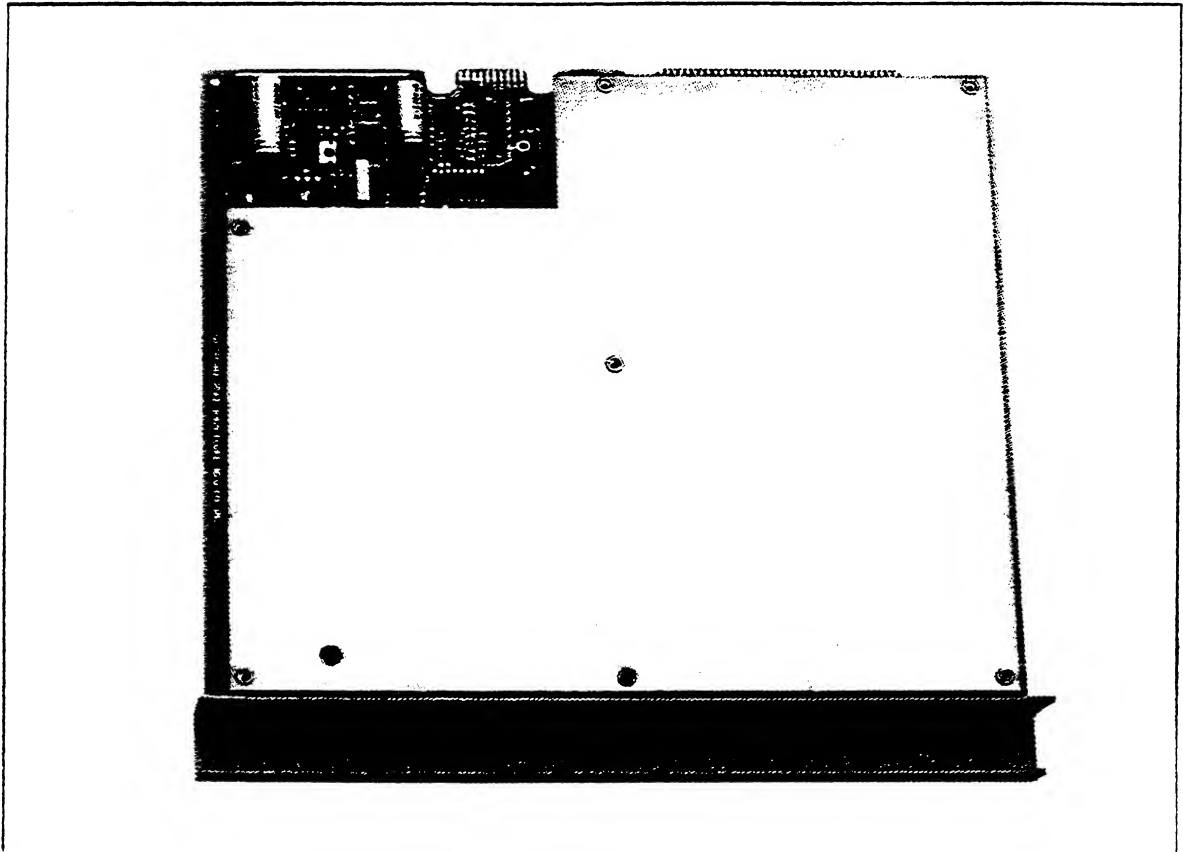
Figure 161-1. A/D Converter

Operating parameters of the A/D Converter are established through the Front End command structure. With one A/D Converter installed, the Front End reads up to 16 input channels per second. If a reading rate higher than 16 channels per second is desired, the rate can be increased by

installing one or two additional A/D Converters in the mainframe. Each additional A/D Converter increases the reading rate by varying amounts depending on the system configuration, but reduces the maximum number of mainframe channels by 20 since another slot has been occupied.

Each A/D Converter supports a maximum of five, 20-channel Thermocouple/DC Volts Scanners (-162) or RTD/Resistance Scanners (-163), thereby providing up to 100 channels. A total of 15 A/D Converters may be installed in a Front End system when 2281A Extender Chassis are used. Like the Front End mainframe, each 2281A Extender Chassis supports a maximum of 100 channels.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: A/D Converter theory of operation, performance tests, calibration procedures, the parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are provided in the Helios I System Manual. Option specifications are located in the appendices to this manual and the System Manual.

The test equipment required to perform the procedures in this subsection is listed in Table 161-1.

A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

THEORY OF OPERATION

The A/D Converter theory of operation begins with a functional description of the A/D Converter, followed by a block diagram analysis that describes the operation of each major circuit block on the A/D Converter assembly. The theory of operation ends with a circuit analysis of each block in the block diagram.

Where necessary, block diagrams and simplified schematics are included with the text. The schematic diagrams for the A/D Converter are located at the end of this option subsection.

Overall Functional Description

The -161 High Performance A/D Converter measures dc voltages received from scanner option channels and sends the measurement results to the Front End controller in digital form over the serial link bus.

At least one scanner and input connector option must be used with the A/D Converter if the Front End is to acquire measurement data.

Table 161-1. Required Test Equipment for -161

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	+/- 31.3 mV +/- 20 uV +2.048V +/- 50 uV -2.048V +/- 2 uV of +2.048 500 mV +/- 20 uV 6.2V +/- 155 uV 6.8V +/- 0.1V 5.0V +/- 100 uV 7.9V +/- 200 uV *63V +/- 800 uV 1.008V +/- 40 uV	Fluke 343
100:1 Divider	+/- 0.005%	Fluke Y2022
Digital Multi-meter (DMM)	+/- 10V +/- 0.06V 50.0 mV +/- 0.001 mV 500.0 mV +/- 0.005 mV	Fluke 8505A
Resistor	1 kilohm +/- 5%	Fluke Part No. 108597
Resistor	10 kilohm +/- 5%	Fluke Part No. 109165
Thermocouple/DC Volts Scanner	NA	Fluke Option -162 (no substitute)
Isothermal Input Connector	NA	Fluke Option -175 (no substitute)
Voltage Input Connector	NA	Fluke Option -176 (no substitute)
Calibration/ Extender Fixture	NA	Fluke Accessory Part No. 648741 (no substitute)

* 63V output is used for only one optional test.

Block Diagram Analysis

Figure 161-2 illustrates the A/D Converter in block diagram form. The following paragraphs discuss the function of each of the blocks in the diagram.
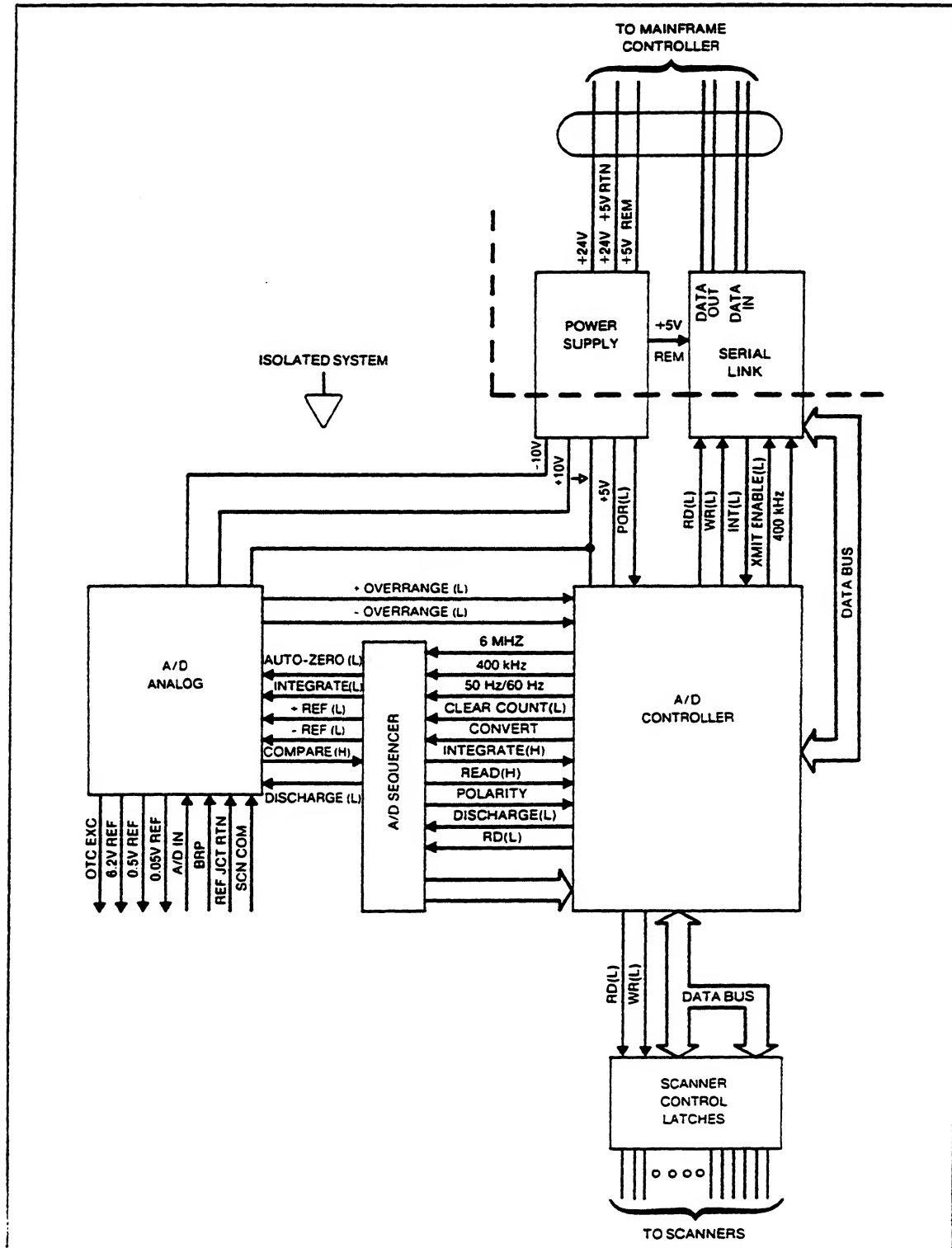
Figure 161-2. A/D Converter Block Diagram

POWER SUPPLY

The Power Supply converts incoming dc power from the serial link into isolated +10V, -10V, and +5V dc for the scanners and the measurement circuitry, as well as +5V dc for the serial link.

A reset signal is transmitted by the Power Supply to the A/D Controller upon power-up. Reference voltages produced by the A/D Analog block are used by the Power Supply to regulate the +10 and -10 output voltages.

SERIAL LINK

The Serial Link allows the A/D Controller to exchange commands and measurement data with the Front End mainframe controller.

The bidirectional serial transmissions are electrically isolated, buffered, and converted to signals that the A/D Controller can use. The serial link circuitry sends an interrupt signal and data to the controller while the controller returns data and a transmitter enable signal.

A/D CONTROLLER

The A/D Controller performs the tasks of maintaining the communication link, selecting scanner modes and channels, and invoking A/D conversions. The controller supplies 6-MHz and 400-kHz clocks, line frequency data, and conversion commands to the A/D Sequencer, and in return, it monitors the progress of conversions through the incoming integrate, read, and polarity lines. The controller is advised of impending overrange measurements by two additional lines that come from the A/D Analog block. By writing into the Scanner Control Latches, the controller manipulates many control lines that direct the scanners.

A/D SEQUENCER

The A/D Sequencer responds to a conversion command from the controller and generates the timed control signals that the A/D Analog block needs to perform a dual-slope analog-to-digital conversion. The read interval of the conversion cycle is timed by this block.

A/D ANALOG

The A/D Analog block accepts dc input voltages from the scanners and converts these inputs to a time interval that is proportional to their magnitude. Here, stable reference voltages are also generated for the Power Supply section and the scanners.

SCANNER CONTROL LATCHES

The scanner control latches are controlled by the A/D Controller, thereby enabling readings on the individual scanner channels.

Detailed Circuit Description

POWER SUPPLY

DC-DC Converter

Isolation of the A/D circuitry is provided by T1 (which is also the core of the dc-dc converter) where T1, U1, U34, U49, Q1, and Q2 comprise a flyback type of switching regulator converter. Incoming dc power is applied to the primary of T1 for an interval generated by U1, causing the primary current to ramp up to approximately 1-ampere peak before Q1 and Q2 are turned off. The energy stored in T1 is then released through CR10, CR11, CR12, and CR13 into C5, C17, C18, and C19. The 5.4V (nominal) on C18 is sampled by R82 and R11 and a feedback error signal is generated by U49, which is relayed to U1 through isolator U34. The duty cycle of Q1 and Q2 is then adjusted by U1 to maintain C18 at 5.4V despite load changes and variations in the serial link supply voltage. Typical waveforms are shown in Figure 161-3.

$V_{CE}^{(Q1)} \sim 10V/DIV$

$I_C^{(Q1)} \sim 0.5A/DIV$

ANODE OF CR 12 REF
TO TP2÷0V/DIV

A/D POWER SUPPLY
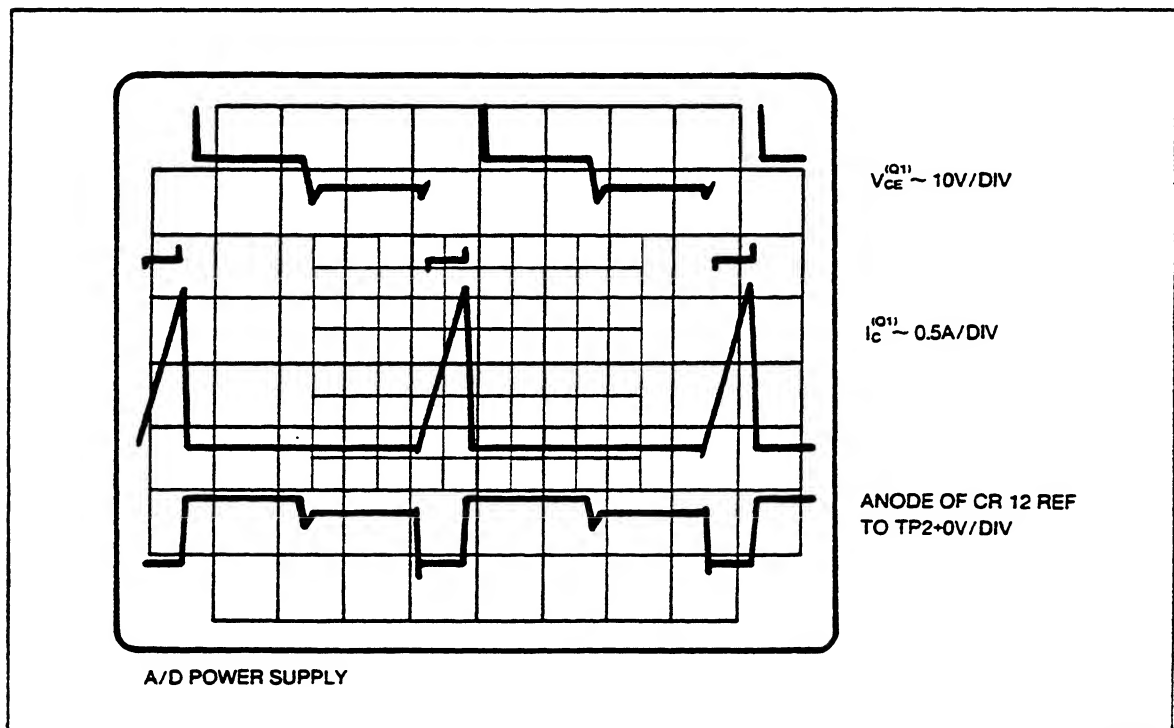
Figure 161-3. DC-DC Converter Typical Waveforms

The voltage on C17, C18 and C19 is regulated further by U33, U49, Q5, Q9, Q10, Q11, Q24, and Q25 to obtain precise +10V, -10V, and +5V dc voltages to power the A/D Converter and scanners. The +10V supply is referenced to zener diode VR5 within the A/D Analog block. The -10V supply is referenced to the +10V supply. The +5V supply is derived from U35, a 2.5V reference, which is also the reference for the switching regulator loop.

The voltage on C5 (5V nominal) is used to power the serial link interface circuits and is only regulated by its coupling to the switching regulator loop through T1.

Reset Generator

When power is first applied to the A/D Converter, Q6 is turned on by R53, and the Power-On Reset Line to the controller is held low. U15 compares the voltage on C46 to a 1.22V reference to determine whether the +5V supply is within tolerance. Once the supply voltage has stabilized, C46 is allowed to charge through R48 and R56, generating a delay of approximately 50 ms before C46 charges to 1.22V causing U15 to remove the drive to Q6, and allowing the Power-On Reset line to be pulled high by R51. At this point Q7 is turned on to light the POWER indicator DS1. For test purposes, this reset sequence can be triggered by momentarily grounding Test Point 44 to TP 2.

SERIAL LINK

Differential line drivers U2 and receiver U3 transmit and receive information through transient suppression networks consisting of resistors R12, R13, R14, R15, R18, R19, R20 and R21 and diodes CR1 through CR8 in conjunction with VR2.

Incoming data from the mainframe controller assembly, which can be monitored at Test Point 30, is fed into UART U17 through optocoupler U5. Upon receipt of a data byte, U17 interrupts microprocessor U10 in the A/D Controller block.

Data destined for the mainframe controller from the A/D is clocked out of the UART through isolator U4 to the line drivers in U2. This data to be transmitted can be observed at Test Point 32. The drivers are enabled by a Xmit Enable signal from the A/D Controller that must also pass through U4. The driver outputs remain in a high-impedance state when not enabled.

A/D CONTROLLER

The A/D Control circuitry consists of an 8-bit microprocessor, U10, that executes firmware stored in a PROM, U26. The lower eight bits of the PROM address is captured in an octal latch, U36, on the rising edge of the address latch enable (ALE(L)) signal from the microprocessor. The clock for the microprocessor is derived from a 6.0 MHz crystal, Y1, in conjunction with U18.

U27 and U28 are CMOS RAMs used to store the calibration constants of the scanners associated with the A/D Converter. Data is read from or written to the RAMs by the microprocessor by using the RD(L), WR(L), and P1-1 (pin 28 of U10).

A/D SEQUENCER

The A/D Sequencer consists of three functional blocks: the integrate timer, the read timer, and the autozero flip-flop. The integrate timer generates the integrate control signal of 16.666 or 20.000 ms duration. The read timer asserts the appropriate polarity reference signal and measures the interval to which it is applied. The autozero flip-flop places the converter into the autozero mode when not performing a conversion.
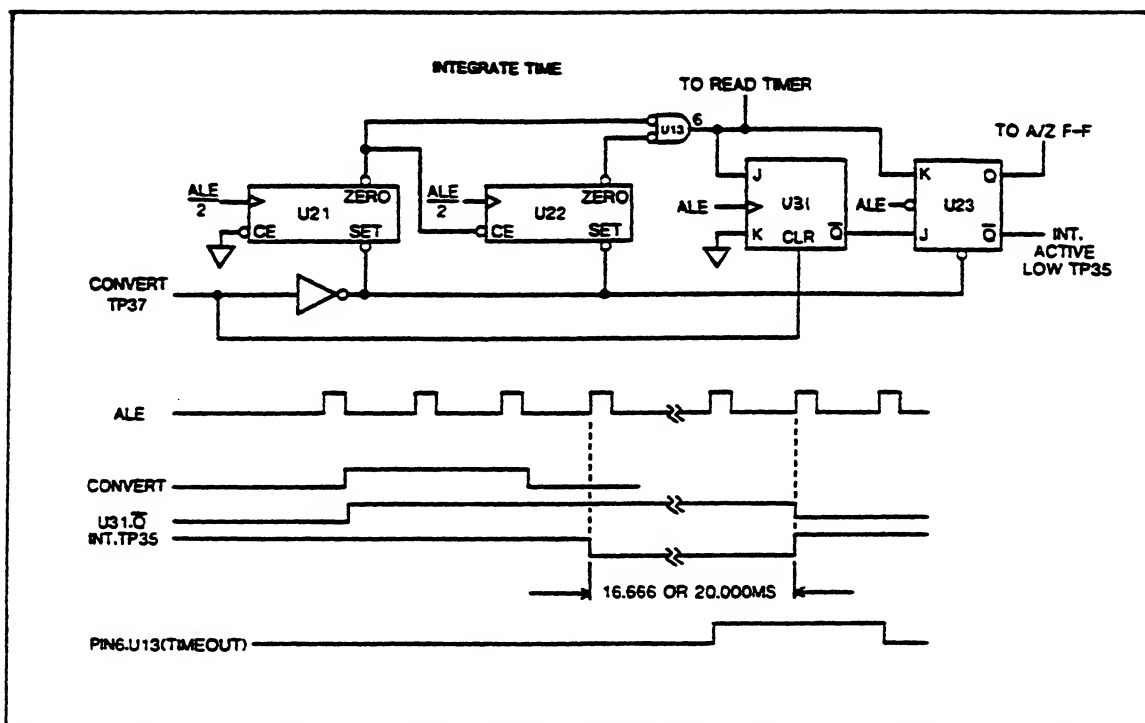
Figure 161-4. Integrate Timer Simplified Schematic and Timing Diagram

o   Integrate Timer

Refer to Figure 161-4 for a simplified schematic and timing diagram of the integrate timer. In response to a convert command from the A/D controller, J-K flip-flops U31 and U23 are reset, and counters U21 and U22 are loaded. The next ALE pulse sets U23, asserting the INTG(L) signal. Subsequent ALE pulses decrement the counters until both reach zero, causing U13 to output a timeout signal. The next ALE pulse toggles U23 to terminate the INTG(L) signal and sets U31 to prevent spurious integrate commands.

o   Read Timer

Refer to Figure 161-5 for a simplified schematic and timing diagram of the read timer. The timeout signal from the integrate timer latches the state of the COMP(H) into U12. U12 selects which reference control line (+REF or -REF) is to be asserted during the read interval. The timeout signal is gated through U40 and U13 to U23 allowing the same ALE pulse that terminates the integrate signal to set U23 and commence the read interval. The READ(H) signal (TP 34) enables U19 and U30 to count the 6-MHz system clock and thereby measure the duration of the read period. U13 and U18 detect the eventual change in comparator state and reset U23 when COMP(H) changes, ending the read interval. U32 and U20 prevent switching glitches from appearing as a comparator transition signal by preventing U23 from being reset until 20 microseconds into the read period. The eventual reset to U23 by COMP also resets U31, inhibiting read timer activity until a subsequent integrate cycle is initiated.
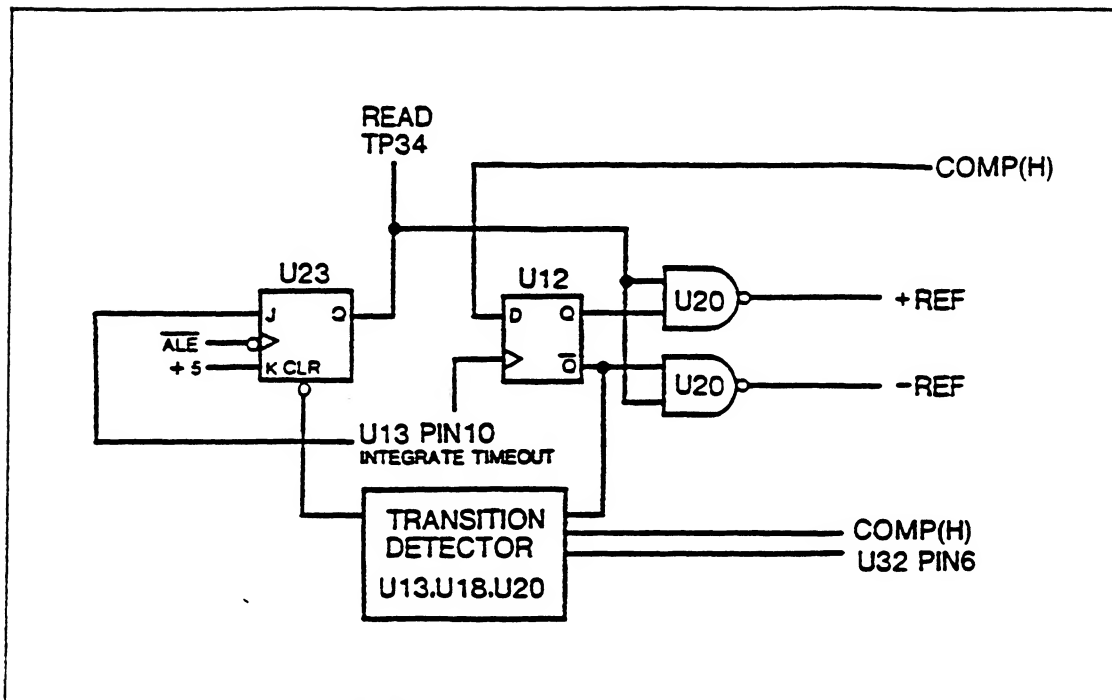
Figure 161-5. Read Timer Simplified Schematic and Timing Diagram

o   Autozero Flip-Flop

When the conversion cycle ends, U12 is clocked, and the Auto-Zero control signal, AZ(L), is asserted low. The system remains in this state until another integrate cycle is entered when the integrate signal resets the autozero flip-flop causing AZ(L) to go high.

A/D ANALOG

Figure 161-6 shows the major components of the dual-slope converter that dominates this circuit block as well as the timing relationships of the control signals and the circuit waveforms as they appear during typical conversion cycles.

A conversion cycle begins with integrate when Q20 turns on and applies the scanner output voltage to the amplifier consisting of Q16 and U44. The amplifier output is integrated by the stage composed of Q13, U43, R77, and C38 as long as the integrate signal is asserted. The integration of the dc input appears as a ramp waveform that can be observed at Test Point 48.

At the end of the integrate period, Q20 is turned off and either Q17 or Q18 is turned on. This applies a stable reference voltage to the integrator with a polarity opposite to the input previously integrated. The integrator in turn ramps back toward zero. The integrator output is amplified by a stage consisting of U43, R87, and R90 before reaching the comparator U42. The amplifier increases the slope of the integrator ramp that is applied to the comparator to facilitate an accurate zero crossing detection by the comparator.
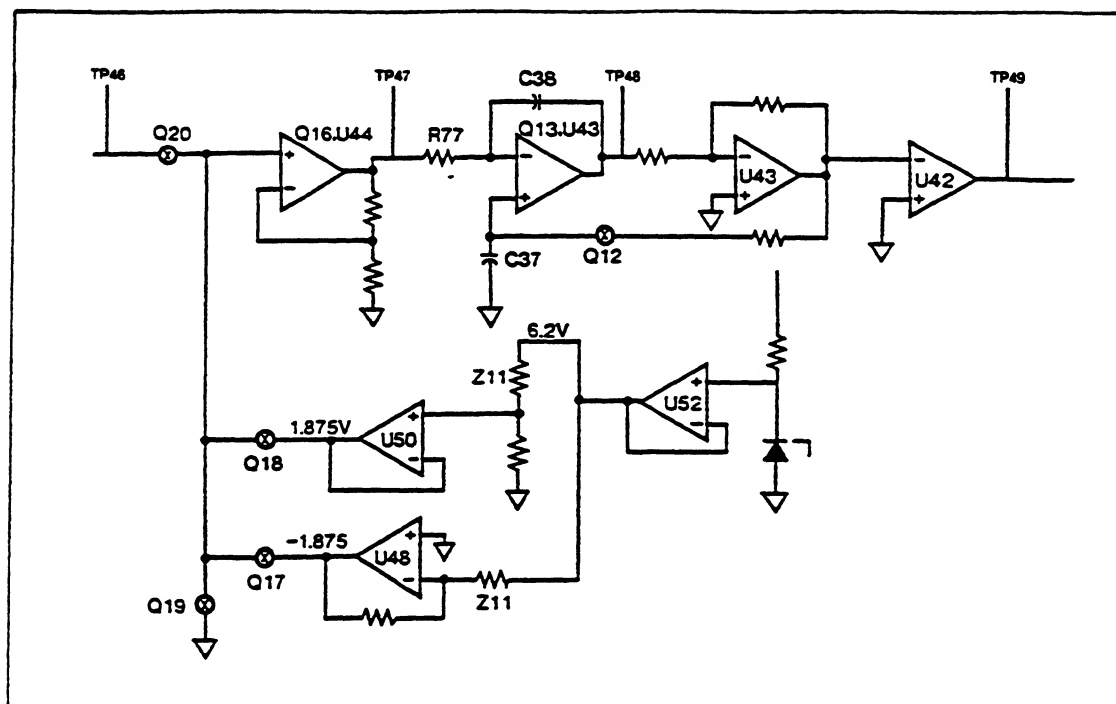
Figure 161-6. A/D Dual-Slope Converter

Once the comparator changes state, the reference is removed from the integrator by turning off Q17 or Q18 and turning on Q19, Q12, and Q14 and placing the converter in the autozero mode. During autozero, amplifier offsets are stored on C37 for use in negating the integrate and read errors that would otherwise occur.

Offscale or overvoltage inputs are detected by comparator U47. Should an out-of-range voltage appear at the A/D input, Q21 is turned on to ensure that the input filter capacitor C59 is not adversely affected. At the same time, an overload bit is pulled low to flag the A/D controller so that a measurement will not be made.

SCANNER CONTROL LATCHES

The A/D Converter generates 21 control signals to select measurement channels and ranges on the connected scanners. The binary representations of the scanner address and channel address to be measured are latched into U6 and U7 by U10 and U37. The scanner address is further decoded by U11 into one of five scanner select lines SCNS[1:5](H) and a sixth signal that is used by the A/D ANALOG block to discharge its input filter DISCHG(H).

U9 and U14 accept the binary representations of the ranging bits RNG0(L) and RNG1(L) in addition to the bits that determine the scanner mode: Zero (ZERO(H)), calibrate (CAL(H)), discharge inhibit (DISCHG INH(H)), and

reference junction enable (REF JCT EN(H)). U14 also stores the line frequency bit that determines the integration period of the Intergrate Timer.

U8 gates the scanner type bits SCN[0:2](H) onto the data bus. U25 gates the setting of the A/D Address switch S1 onto the bus as well as the status of the RDY(H) line that is returned from the scanners.

A/D Operation

The A/D Converter does not initiate tasks independently, but responds to commands from the Front End mainframe controller. Six commands (listed and described in the following bulleted paragraphs) direct the A/D Converter through all of the jobs demanded of it.

o   Reset Command

   This command initializes the A/D Controller and its RAM. The reset command elicits no response from the A/D Converter.

o   Configuration Request

   The A/D Converter responds to this command by sending the type identifier of each associated scanner. One type identifier is sent for each block or decade of channels. Thus, an A/D Converter with three adjoining DC Volts Scanners would respond with six different block addresses during a system-wide configuration check.

o   Calibrate Command

   The A/D Converter measures the offsets and gains of each range of the DC Volts and RTD/Ohms Scanner connected to it. From these measurements the A/D Converter computes and stores correction constants for use in adjusting subsequent measurements. The calibrate command contains line frequency information that the A/D Converter uses to determine the integration period. Calibration is commanded on approximately ten-minute intervals and at power-on. The A/D Converter does not send a response to the calibration command.

o   Measurement Command

   The A/D Converter performs measurements on desired scanner channels in the ranges identified within the command. Normally the A/D Converter responds to a measurement request with an acknowledgement that the command was understood. If the A/D Converter is in an uncalibrated state, as might happen if serial link power had been interrupted, the A/D Converter does not send a response.

o   Status Request

   The A/D responds to a status request command with a Ready or a Not Ready response, indicating whether or not it has completed the measurement task previously commanded.

o   Measurement Results Request

The A/D Converter responds by sending back the results of the measurements most recently performed. If the A/D Converter does not have readings to transmit, it does not send a response.

GENERAL MAINTENANCE

The A/D Converter normally does not require cleaning, unless dirt, dust, or other contamination is visible on the surface of the Converter. Follow cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

There are four performance tests for the -161 A/D Converter. All four tests may be performed in sequence to verify overall operation of the A/D Converter, or the tests may be run independently.

The four performance tests are:

o   Address Response Test

o   Accuracy Verification Test

o   Overrange Indication Test

o   Open Thermocouple Response Test

These performance tests verify that the A/D Converter performs properly and that it meets all specified accuracy tolerances. If calibration of the assembly is required, refer to the Calibration procedures that follow the performance tests in this subsection.

Address Response Performance Test

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

The Address Response performance Test checks to see if the Front End mainframe controller can communicate properly with the A/D Converter address switch set to a variety of positions that exercise all address switch lines. (Address switch settings and channel ranges for the A/D Converter are shown on Table 161-2.)

Table 161-2. A/D Address Switch Settings and Channel Ranges

ADDRESS SWITCH SETTING	CHANNEL RANGE
0	0 through 99
1	100 through 199
2	200 through 299
3	300 through 399
4	400 through 499
5	500 through 599
6	600 through 699
7	700 through 799
8	800 through 899
9	900 through 999
10	1000 through 1099
11	1100 through 1199
12	1200 through 1299
13	1300 through 1399
14	1400 through 1499
15	NOT USED

To conduct the Address Response Performance Test, perform the following procedure:

1. Switch OFF power to the Front End.

2. Disconnect the ac line power cord and all other high voltage inputs.

3. Set the A/D Converter address switch to "0" and install the A/D Converter in the Front End option slot second from the bottom. Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

4. Remove all other installed options to eliminate addressing conflict.

5. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

   Install the connector on the scanner.

6. Reconnect power to the Front End and switch power ON.

7. Connect the calibrator output to the input connector test leads.

8. Set the calibrator output to 7.9000V dc.

9. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM  <CR>

DEF CHAN(0)=DVIN,MAX=7.9  <CR>

FORMAT=DECIMAL  <CR>

SEND CHAN(0)  <CR>
```

The value returned for the selected channel should be approximately 7.9V.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
```

```
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
100   GOSUB 300
120   PRINT #1,"def chan(0)=dvin,max=7.9"
125   GOSUB 300
130   PRINT #1,"format=decimal"
140   GOSUB 300
150   REM make measurement and read in response
160   PRINT #1,"send chan(0)"
170   INPUT #1,M$
180   PRINT USING "##.###";VAL(M$);
190   PRINT " Volts DC"
200   END
300   REM wait for message accepted prompt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1%
50    OPEN "KB1:"AS OLD FILE 2%
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"count=off"
110   GOSUB 300
120   PRINT #1,"def chan(0)=dvin,max=7.9"
130   GOSUB 300
140   PRINT #1,"format=decimal"
150   GOSUB 300
160   REM make measurement and read in response
170   PRINT #1,"send chan(0)"
180   INPUT #2,M$
190   PRINT USING "S##.###",VAL(M$);
200   PRINT " Volts DC"
210   END
300   REM wait for message accepted prompt
310   INPUT #2,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

The value returned for the selected channel should be approximately 7.9V.

10. Switch Front End power OFF.

11. Using a common screwdriver, set the address switch on the A/D Converter to "1". Switch power to the Front End ON.

12. Program the Front End to take a measurement on channel 100 by substituting channel "100" for "0" in both the DEF CHAN and SEND CHAN commands of step 9.

13. Repeat steps 10 through 12 for channel 200 (A/D address set to 2), 400 (A/D address set to 4), 800 (address set to 8), and 1400 (address set to 14). The measurement on each channel should be approximately 7.9V.

14. This completes the Address Response Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the -161 High Performance A/D Converter.

Accuracy Verification Test

All voltage readings taken by the Front End depend on the accuracy of the A/D Converter. The Accuracy Verification Test checks the A/D Converter to see if its voltage measurement accuracy is within specifications.

To conduct the Accuracy Verification Test, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volt Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on either the -176 Voltage Input Connector or the -175 Isothermal Input Connector. Install the connector on the scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the calibrator output to the input of the 100:1 divider. Connect the divider output to the input connector test leads.

6. Set the calibrator output to 6.2000V (62 mV out of the divider).

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

        MODE=TERM <CR>

        DEF CHAN(0)=DVIN, MAX=0.062 <CR>

        FORMAT=DECIMAL <CR>

        SEND CHAN(0) <CR>

The returned value for channel 0 should be 62 mV +/- 0.014 mV.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port, empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50  PRINT #1,CHR$(3);
60  REM Set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
```

```
120 PRINT #1,"def chan(0)=dvin,max=0.062"
125 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #1,M$
180 PRINT "chan 0 = ";
190 PRINT USING "##.######";VAL(M$)
200 PRINT " Volts DC"
210 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0)=dvin,max=0.062"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0)"
170  INPUT #2,M$
180  PRINT "chan 0 = ";
190  PRINT USING "S##.######",VAL(M$);
200  PRINT " Volts DC"
210  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The returned value for channel 0 should be 62 mV +/- 0.014 mV.

8. Change to the 512 mV voltage range by redefining channel 0.

   To do this in the Terminal Mode, send the following command:

   DEF CHAN(0)=DVIN, MAX=0.5 <CR>

   To do this in the Computer Mode, change the BASIC statement in line 120 to:

   PRINT #1,"def chan(0)=dvin, max=0.5"

9. Set the calibrator to 0. Remove the 100:1 divider and connect the calibrator output directly to the connector test leads on channel 0.

10. Set the calibrator to output 500 mV.

11. Request a measurement and verify that channel 0 returns a value of 500 mV +/- 0.1 mV.

    If you are in Terminal Mode, take the measurement by sending the following command:

    SEND CHAN(0) <CR>

    If you are in the Computer Mode, run the program as modified in step 8.

12. Change to the 8V range by redefining channel 0.

    To do this in the Terminal Mode, send the following command:

    DEF CHAN(0)=DVIN, MAX=7.9

    To do this in the Computer Mode, change the BASIC program statement in line 120 to send this command.

13. Set the calibrator output to 7.9000V.

14. Request another measurement as in step 11.

    Verify that the returned value is within 7.9V +/- 0.002V.

15. Change to the 64V range by redefining channel 0.

    To do this in the Terminal Mode, send the following command:

    DEF CHAN(0)=DVIN, MAX=63 <CR>

    If you are in the Computer Mode, change the BASIC program statement in line 120 to send this command.

16.   Set the calibrator output to 63.000V.

17.   Request another channel 0 measurement.

The returned value should be 63V +/- 0.02V.

18.   The Accuracy Verification Test is now complete.

Continue with the Overrange Indication Test if you are conducting a complete performance test of the -161 High Performance A/D Converter.

Overrange Indication Test

The Overrange Indication Test determines if the A/D Converter can detect and communicate a channel overrange condition to the mainframe controller.

To conduct the Overrange Indication Test, perform the following procedure:

1.   Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2.   Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End.

Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

3.   Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

Install the connector on the scanner.

4.   Reconnect the ac line cord to the Front End and switch the power ON.

5.   Connect the calibrator output to the input of the 100:1 divider.

Connect the divider output to the input connector test leads.

6.   Set the calibrator output to 6.8V (68 mV out of the divider).

7.   Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End:

        MODE=TERM <CR>

        DEF CHAN(0)=DVIN,MAX=0.062 <CR>

        FORMAT=DECIMAL <CR>

        SEND CHAN(0) <CR>

The value displayed for channel 0 should be 9.99999E+37.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
110  PRINT #1,"def chan(0)=dvin,max=0.062"
120  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0)"
170  INPUT #1,M$
```

```
180  PRINT M$
190  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0)=dvin,max=0.062"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT #1,"send chan(0)"
180  INPUT #2,M$
190  PRINT M$
200  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value displayed for channel 0 should be 9.99999E+37.

8. Perform PROCEDURE 8A or PROCEDURE 8B as appropriate.

PROCEDURE 8A. TERMINAL MODE

Send the following command to inspect the fault condition:

    LIST ERROR <CR>

The following error message should be displayed:

    Chan(0)-Out of range

PROCEDURE 8B. COMPUTER MODE

Run one of the following BASIC programs (or a similar one appropriate to your host).

Program for IBM PC:

```
10   CLS
20   REM send the fault condition
30   OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40   PRINT #1,"list error"
50   INPUT #1,N
60   PRINT N
70   IF N=0 THEN 120
80   FOR I=1 TO N
90   LINE INPUT #1,E$
100  PRINT E$
110  NEXT I
120  END
```

Program for 1722A:

```
10   PRINT CHR$(27);"[2J";
20   REM send the fault condition
30   PRINT #1,"list error"
40   INPUT #2,N
50   PRINT N
60   IF N=0 THEN 110
70   FOR I=1 TO N
80   INPUT LINE #2,E$
90   PRINT E$
100  NEXT I
110  END
```

The displayed response should be:

```
        1
      0,15
```

The top number, "1", indicates that one error was logged. The lower set of numbers, "0,15", indicates that error 15 was logged on channel 0. Error 15 is an "Out of range" condition.

9. The Overrange Test is complete.

Continue with the Open Thermocouple Response Test if you are conducting a complete performance test of the -161 High Performance A/D Converter and you have not already performed the test in the Thermocouple/DC Volt Scanner performance test section.

Open Thermocouple Response Test

The Open Thermocouple Response Test determines if the A/D Converter can detect and communicate an open thermocouple condition on a channel to the mainframe controller.

NOTE

The Open Thermocouple Response Test is part of the performance test for the -162 Thermocouple/DC Volts Scanner. The test is repeated here because each assembly contains part of the circuitry that checks for an open thermocouple. If both the A/D Converter and the Thermocouple/DC Volts Scanner are being tested, the open thermocouple test need only be performed once.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on the -175 Isothermal Input Connector. Install the connector on the scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the test leads from the Isothermal Input Connector to a 1-kilohm resistor.

6. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0)=TC,TYPE=JNBS <CR>

FORMAT=DECIMAL <CR>

TUNIT=CELSIUS <CR>

SEND CHAN(0) <CR>
```

The value displayed for channel 0 should equal the ambient temperature +/- 2 degrees Celsius.

PROCEDURE B. COMPUTER MODE

The following BASIC programming examples will cause the Front End
to take a thermocouple measurement on channel 0. One program was
written for an IBM PC and one for a Fluke 1722A Instrument
Controller.

NOTE

These programs are offered as examples. If you do
not have an IBM PC or a Fluke 1722A Instrument
Controller, enter a program that will run on your
host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port and empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
110  PRINT #1,"def chan(0)=tc,type=jnbs"
120  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  PRINT #1,"tunit=celsius"
160  GOSUB 300
170  REM make measurement and read in response
180  PRINT #1,"send chan(0)"
190  INPUT #1,M$
200  PRINT M$
210  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
```

```
70   REM set up computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0)=tc,type=jnbs"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  PRINT #1,"tunit=celsius"
170  GOSUB 300
180  REM make measurement and read in response
190  PRINT #1,"send chan(0)"
200  INPUT #2,M$
210  PRINT M$
220  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value displayed for channel 0 should equal the ambient
temperature +/- 2 degrees Celsius.

7. Replace the 1-kilohm resistor with a 10-kilohm resistor to simulate
    a high resistance or open thermocouple.

8. Request a measurement and verify that the returned value is:

    9.99999E+37

9. Perform PROCEDURE 9A or PROCEDURE 9B as appropriate.

PROCEDURE 9A. TERMINAL MODE

Send the following command to inspect the fault condition:

    LIST ERROR <CR>

The following error message should be displayed:

    chan(0)-open tc

PROCEDURE 9B. COMPUTER MODE

Run one of the following BASIC programs (or a similar one
appropriate to your host).

Program for IBM PC:

```
10   CLS
20   REM send the fault condition
30   OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40   PRINT #1,"list error"
```

```
50   INPUT #1,N
60   PRINT N
70   IF N=0 THEN 120
80   FOR I=1 TO N
90   LINE INPUT #1,E$
100  PRINT E$
110  NEXT I
120  END
```

Program for 1722A:

```
10   PRINT CHR$(27);"[2J";
20   REM send the fault condition
30   PRINT #1,"list error"
40   INPUT #2,N
50   PRINT N
60   IF N=0 THEN 110
70   FOR I=1 TO N
80   INPUT LINE #2,E$
90   PRINT E$
100  NEXT I
110  END
```

The displayed response should be:

```
   1
 0,16
```

The top number, "1", indicates that one error was logged. The lower set of numbers, "0,16", indicate that error number 16 was logged on channel 0. Error 16 is an Open thermocouple.

10. Disconnect the 10-kilohm resistor and the test leads from the Isothermal Input Connector.

11. Performance testing of the -161 High Performance A/D Converter is complete.

CALIBRATION

Perform the following procedures to calibrate the -161 High Performance A/D Converter.

NOTE

Calibrate the -161 A/D Converter only if it fails the Accuracy Verification Tests.

The 161 A/D Converter is calibrated in two stages: first, verify that power supply voltages are within specifications; second, calibrate the zero, full-scale, and reference for the A/D Converter.

WARNING

**THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES
THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED
PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT.
TURN OFF THE COMPUTER FRONT END AND REMOVE ALL
POWER SOURCES BEFORE STARTING THE FOLLOWING
PROCEDURE.**

Power Supply Verification Procedure

To verify that power supply voltages are within specification, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Set the address switch on the A/D Converter to "0" and install the A/D Converter in the second option slot from the bottom of the Front End, leaving one slot open below it.

3. To eliminate addressing conflict, remove any other installed options.

4. Install the Calibration Extender/Fixture/ (Fluke Part No. 648741) in the bottom slot, just below the A/D Converter. Set the slide switch on the Calibration Fixture to the CAL position.

NOTE

Do not install a scanner at this time.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Set the DMM to read +5V with 1 mV resolution.

7. Connect the DMM to the +5V and LOGIC COMMON test points on the Calibration Fixture, observing correct polarity.

8. Verify a DMM reading of +5.000V +/- 0.125V.

9. Set the DMM to read 10V with 1 mV resolution. Move the DMM positive lead to the +10V test point on the Calibration Fixture.

10. Verify a DMM reading of +10.067V +/- 0.140V.

11. Move the DMM positive lead to the -10V test point on the Calibration Fixture.

12. Verify a DMM reading of -10.067V +/- 0.360V.

13. This completes the Power Supply Verification Test.

14. If all voltages are within tolerance, proceed to Zero, Full-Scale, and Reference Calibration below. If the power supply voltages are not within the stated tolerances, the A/D Converter must be repaired.

Zero and Full-Scale Reference Calibration

Perform the following procedure for Zero, Full-Scale, and Reference Calibration:

1. Perform steps 1 through 5 of the Power Supply Verification Procedure.

2. Remove the DMM test leads from the Calibration Fixture.

3. Before proceeding further, be sure that the A/D Converter has been ON and its temperature stabilized for at least 30 minutes.

4. Install a 100:1 voltage divider (Fluke Y2022) on the calibrator.

5. Set the calibrator for an output of +31.3 mV dc (providing +313 uV at the voltage divider output).

   Connect the voltage divider pos (+) volts terminal to the A/D Converter INPUT test point on the Calibration Fixture with a test lead. Connect the voltage divider neg (-) volts terminal to the ANALOG COMMON test point on the Calibration Fixture with another test lead.

6. Turn the A/D Converter ZERO WIDTH potentiometer fully clockwise.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether calibration will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0)=CAL <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>
```

Set the A/D zero level as follows:

NOTE

The zero level adjustment procedure will require polarity reversal of the test leads and issuance of SEND CHAN(0) commands until equal magnitudes are obtained. In the Terminal Mode, repetitive measurements on a selected channel can easily be taken by the sending the repeat command

    ! <CR>

to the Front End each time you want to repeat the measurement.

A1. Note the value returned and displayed on the terminal.

A2. Reverse the test leads. Wait about a minute for the connections and leads to thermally stabilize. Then command the Front End to take another measurement by sending another SEND CHAN(0) command. Again note the value returned.

A3. Adjust the ZERO LEVEL potentiometer on the A/D Converter so that the positive and negative readings are of equal magnitude.

A4. Adjust the ZERO WIDTH potentiometer on the A/D Converter until the magnitude returned is between 7.40000E+01 and 8.60000E+01 (80 +/- 6 counts).

A5. Connect a Fluke 8505A or equivalent DMM as follows:

   a. Connect the LO terminal on the DMM to the ANALOG COMMON test point on the Calibration Fixture.

   b. Connect the HI terminal on the DMM to the 6.2V test point on the Calibration Fixture.

A6. Adjust the 6.2V potentiometer on the A/D Converter for a DMM reading between 6.19995V and 6.20005V.

A7. Disconnect the DMM from the Calibration Fixture.

A8. Remove the divider from the calibrator.

   a. Connect the pos (+) terminal of the calibrator to the A/D Converter INPUT test point on the Calibration Fixture.

   b. Connect the neg (-) terminal of the calibrator to the ANALOG COMMON test point on the Calibration Fixture.

A9. Set the calibrator output to +2.0000V.

A10. Request a measurement by sending the Front End a SEND CHAN(0) command.

A11. Adjust the A/D Converter -1.875V REF potentiometer for a Front End reading of +512,000 +/- 6 counts.

The value displayed on the terminal should be between 5.11994E+05 and 5.12006E+05.

A12. Repeating the measurement for adjustment purposes is required.

Take measurements and adjust the potentiometer until the value displayed is between 5.11994E+05 and 5.12006E+05.

A13. By reversing the two connections made on the Calibration Fixture in step A8, apply -2.000V to the A/D INPUT.

A14. Adjust the A/D Converter +1.875V REF potentiometer for a Front End reading of -512,000 +/- 6 counts.

The terminal should display a value between -5.11994E+05 and -5.12006E+05.

PROCEDURE B. COMPUTER MODE

The following BASIC programming examples will request the A/D to return its measurement in counts. Math is then performed to display a value for the required resolution. One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
```

```
100    GOSUB 300
120    PRINT #1,"def chan(0)=cal"
125    GOSUB 300
130    PRINT #1,"format=decimal"
140    GOSUB 300
150    REM make measurement and read in response
160    PRINT #1,"send chan(0)"
170    INPUT #1,M
180    C=(M/4)+0.5
190    PRINT INT(C);" counts"
200    GOTO 160
210    END
300    REM wait for message accepted prompt
310    INPUT #1,A$
320    IF A$<>"!" THEN GOTO 310
330    RETURN
```

Program for 1722A:

```
10     CLOSE 1,2
20     PRINT CHR$(27);"[2J";
30     REM open communication port and empty Front End buffer
40     OPEN "KB1:"AS NEW FILE 1%
50     OPEN "KB1:"AS OLD FILE 2%
60     PRINT #1,CHR$(3);
70     REM set up Computer Front End
80     PRINT #1,"mode=comp"
90     GOSUB 300
100    PRINT #1,"count=off"
110    GOSUB 300
120    PRINT #1,"def chan(0)=cal"
130    GOSUB 300
140    PRINT #1,"format=decimal"
150    GOSUB 300
160    REM make measurement and read in response
170    PRINT #1,"send chan(0)"
180    INPUT #2,M
190    C=(M/4)+0.5
200    PRINT INT(C);" counts"
210    GOTO 170
220    END
300    REM wait for message accepted prompt
310    INPUT #2,A$
320    IF A$<>"!" THEN GOTO 310
330    RETURN
```

Set the A/D Converter zero level as follows:

    B1. Note the value displayed on the computer.

NOTE

The zero level adjustment procedures require polarity reversal of the test leads until equal magnitudes are obtained.

B2. Reverse the test leads. Wait about a minute for the connections and leads to thermally stabilize.

Note the value returned.

B3. Adjust the ZERO LEVEL potentiometer on the A/D Converter so that the positive and negative readings are of equal magnitude.

Repeat step B2 as often as necessary while this adjustment is being made.

B4. Adjust the ZERO WIDTH potentiometer on the A/D Converter until the magnitude returned is 20 +/- 1 count.

B5. Connect a Fluke 8505A or equivalent DMM as follows:

a. Connect the LO terminal on the DMM to the ANALOG COMMON test point on the Calibration Fixture.

b. Connect the HI terminal on the DMM to the 6.2V test point on the Calibration Fixture.

B6. Adjust the 6.2V potentiometer on the A/D Converter for a DMM reading between 6.19995 and 6.20005V.

B7. Disconnect the DMM from the Calibration Fixture.

B8. Remove the divider from the calibrator.

a. Connect the pos (+) terminal of the calibrator to the A/D INPUT test point on the Calibration Fixture.

b. Connect the neg (-) terminal of the calibrator to the ANALOG COMMON test point on the Calibration Fixture.

B9. Set the calibrator output to +2.0000V.

B10. Stop execution of the program and modify it as follows:

For the IBM PC program, change line 180 to:

C=((M/4)+0.5)-128000

For the Fluke 1722A program, change line 190 to:

C=((M/4)+0.5)-128000

B11. Run the modified program.

B12. Adjust the A/D Converter -1.875V REF potentiometer for a Front End reading of 0 +/- 1 count.

B13. By reversing the two connections made on the Calibration Fixture in step B8, apply -2.000V to the A/D Converter INPUT.

B14. Stop execution of the program and modify it as follows:

For the IBM PC program, change line 180 to:

C=((M/4)+0.5)+128000

For the Fluke 1722A program, change line 190 to:

C=((M/4)+0.5)+128000

B15. Run the modified program.

B16. Adjust the A/D Converter +1.875V REF potentiometer for a Front End reading of 0 +/- 1 count.

B17. Stop execution of the program.

8. Disconnect the calibrator from the Calibration Fixture, and connect the DMM as follows:

   a. Connect the LO terminal of the DMM to the ANALOG COMMON test point on the Calibration Fixture.

   b. Connect the HI terminal of the DMM to the 50 mV REF test point on the Calibration Fixture.

9. Set the DMM to a range having 1 uV resolution.

   Wait one minute for the connection and leads to stabilize thermally before continuing.

10. Adjust the 0.05V potentiometer on the A/D converter for a DMM reading of 50.000 mV within a tolerance of +/- 0.001 mV.

11. Move the DMM HI terminal connection to the 500 mV REF test point on the Calibration Fixture.

12. Adjust the 0.5V potentiometer on the A/D Converter for a DMM reading of 500.000 mV within a tolerance of +/- 0.005 mV.

13. Calibration is now complete.

14. Power down the Front End then turn it back ON to cause the new calibration constants to be measured and stored by the A/D Converter. Now perform the A/D Converter accuracy verification performance test provided earlier in this subsection.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the -161 High Performance A/D Converter is given in Table 161-3.

For parts ordering information, see Section 6 of this manual.

Figure 161-7 is a schematic diagram of the High Performance A/D Converter.

REFERENCE DESIGNATOR -A>-NUMERICS---->	S-------------DESCRIPTION-------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
Table 161-3. -161 High Performance A/D Converter PCA (See Figure 161-7.)						
C 1	CAP,AL,330UF,+100-10%,25V,SOLV PROOF	614404	89536	614404	1	
C 2	CAP,CER,1000PF,+-10%,500V,X5S	357806	60705	562CX5FBA102EF102K	1	
C 3	CAP,CER,1000PF,+-5%,50V,C0G	528539	04222	SR215A102JAA	1	
C 4, 10- 15,	CAP,CER,0.22UF,+-20%,50V,Z5U	519157	04222	SR205E224MAA	14	
C 21- 23, 25,		519157				
C 47, 54, 58		519157				
C 5, 17, 19	CAP,AL,270UF,+100-10%,20V,SOLV PROOF	602656	89536	602656	3	
C 7, 16	CAP,TA,39UF,+-20%,6V	163915	56289	199D396X0006DA2	2	
C 8	CAP,CER,100PF,+-2%,100V,C0G	512848	04222	SR151A101GAA	1	
C 9	CAP,CER,47PF,+-2%,100V,C0G	512368	04222	SR151A470GAA	1	
C 18	CAP,AL,470UF,+100-10%,12V,SOLV PROOF	602649	89536	602649	1	
C 20, 24, 56	CAP,CER,1UF,+-20%,50V,Z5U	436782	04222	SR305E105MAA	3	
C 27, 28, 30,	CAP,AL,47UF,+-20%,16V,SOLV PROOF	643304	62643	LR16VB470M6X0LLV	5	
C 31, 57		643304				
C 29, 33, 34,	CAP,AL,10UF,+-20%,35V,SOLV PROOF	643296	89536	643296	13	
C 39, 40, 44,		643296				
C 45, 49- 52,		643296				
C 60, 61		643296				
C 32, 35, 36	CAP,CER,150PF,+-2%,100V,C0G	512988	04222	SR291A151JAA	3	
C 37	CAP,POLYPR,0.47UF,+-10%,160V	446807	68919	MKP4474K160B	1	
C 38	CAP,POLYPR,0.47UF,+-5%,50V,HERMETIC	364042	89536	364042	1	
C 41, 42	CAP,CER,68PF,+-2%,100V,C0G	362756	04222	SR291A680GAA	2	
C 43	CAP,POLYES,0.1UF,+-10%,50V	696484	68919	MKS2104K50	1	
C 46	CAP,POLYES,0.47UF,+-10%,100V	369124	68919	MKS4474K100	1	
C 53, 62	CAP,CER,0.01UF,+-20%,100V,X7R	407361	04222	SR201C103MAA	2	
C 55	CAP,CER,0.0012UF,+-10%,500V,Z5R	106732	60705	562CCK501EE122KA59	1	
C 59	CAP,POLYPR,1500PF,+-5%,50V	706572	89536	706572	1	
CR 1- 8, 11,	DIODE,SI,50 PIV,1.0 AMP	379412	04713	1N4933	10	
CR 13		379412				
CR 9, 14- 21	* DIODE,SI,BV=75V,IO=150MA,500MW	203323	65940	1N4448	9	
CR 10, 12	DIODE,SI,20 PIV,1.0 AMP	507731	04713	MBR120P	2	
DS 1	LED,RED,90 LEAD PREP,LUM INT=2MCD	604884	89536	604884	1	
E 1	HEADER,1 ROW,.100CTR,4 PIN	417329	00779	103747-4	1	
F 1	FUSE,.25X1.25,0.5A,250V,SLOW	109322	71400	MDA-1/2	1	
H 1	SCREW,FH,P,SS,4-40,.625	887984	89536	887984	3	
H 2	SCREW,PH,P,STL,4-40,.625	868138	89536	868138	4	
H 3	WASHER,FLAT,STL,.128,.187,.030	147728	89536	147728	4	
H 4	WASHER,LOCK,SPLIT,STL,.115,.223,.025	110395	86928	5850-11-22	4	
H 5	RIVET,BUTTON,NYL,.093,.115	658450	0HFJ2	27PIF0039	1	
MP 1	CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	1	
MP 2	INSUL PT,TRANSISTOR MOUNT,DAP,TO-18	175125	07047	10172-DAP	1	
MP 3	BOTTOM SHIELD,ASSY	655506	89536	655506	1	
MP 4	SHIELD A/D TOP	579037	89536	579037	1	
MP 5	HANDLE HI PERFORMANCE A/D,MODIFIED	633263	89536	633263	1	
MP 6	DECAL, OPTION-161	634469	89536	634469	1	
MP 7	HLDR,FUSE,1/4,PWB MT	485219	91833	3529	2	
Q 1	* TRANSISTOR,SI,BV= 80V, 50W,TO-220	535542	89536	535542	1	
Q 2	* TRANSISTOR,SI,NPN,HI-VOLTAGE	370684	04713	MPS-A42	1	
Q 3- 5, 9,	* TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	04713	2N3906	5	
Q 23	*	195974				
Q 6- 8, 22,	* TRANSISTOR,SI,NPN,SMALL SIGNAL,TO-92	218396	04713	2N3904	5	

Table 161-3. -161 High Performance A/D Converter PCA (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S---------------DESCRIPTION-------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	N O T -E-
Q 24	*	218396				
Q 10	* TRANSISTOR,SI,PNP,SMALL SIGNAL	340026	55464	MPS6563	1	
Q 11	* TRANSISTOR,SI,NPN,SMALL SIGNAL	330803	04713	MPS6560	1	
Q 12, 14, 17-	* TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	429977	17856	J2160	7	
Q 21	*	429977				
Q 13, 16	* TRANSISTOR,SI,N-JFET,DUAL,TO-71	419283	89536	419283	2	
Q 15	* TRANSISTOR,SI,NPN,SMALL SIGNAL	242065	04713	2N5089	1	
Q 25	* TRANSISTOR,SI,BV=100V,10W	495689	04713	MPSU56	1	
R 1	RES,CF,1.8K,+-5%,0.25W	441444	59124	CF1/4 182J	1	
R 2	RES,CF,1.5K,+-5%,0.25W	343418	59124	CF1/4 152J	1	
R 3, 41, 50	RES,CF,330,+-5%,0.25W	368720	59124	CF1/4 331J	3	
R 4, 44, 45	RES,CF,510,+-5%,0.25W	441600	59124	CF1/4 511J	3	
R 5, 6, 26,	RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF-55 1002F T-1	10	
R 35, 42, 46,		168260				
R 47, 95,120,		168260				
R 121		168260				
R 7	RES,MF,15.8K,+-1%,0.125W,100PPM	293688	91637	CMF-55 1582F T-1	1	
R 10	RES,MF,45.3K,+-1%,0.125W,100PPM	234971	91637	CMF-55 4532F T-1	1	
R 11	RES,MF,40.2K,+-1%,0.125W,100PPM	235333	91637	CMF-55 4022F T-1	1	
R 12, 13, 18,	RES,CF,51,+-5%,0.25W	414540	59124	CF1/4 510J	4	
R 19		414540				
R 14, 15, 22,	RES,CF,270,+-5%,0.25W	348789	59124	CF1/4 271J	5	
R 38, 39		348789				
R 16, 17, 23,	RES,CF,5.6K,+-5%,0.25W	442350	59124	CF1/4 562J	4	
R 40		442350				
R 20, 21	RES,CF,30,+-5%,0.25W	442228	89536	442228	2	
R 24, 49, 53,	RES,CF,10K,+-5%,0.25W	348839	59124	CF1/4 102J	8	
R 55, 57, 58,		348839				
R 122,124		348839				
R 25,112,118,	RES,CF,100,+-5%,0.25W	348771	59124	CF1/4 101J	4	
R 119		348771				
R 27	RES,MF,9.53K,+-1%,0.125W,100PPM	288563	91637	CMF-55 9531F T-1	1	
R 29, 30, 34,	RES,CF,1.1K,+-5%,0.25W	348797	89536	348797	4	
R 74		348797				
R 31	RES,CF,820,+-5%,0.25W	442327	59124	CF1/4 821J	1	
R 32, 33	RES,CF,2.2K,+-5%,0.25W	343400	59124	CF1/4 222J	2	
R 36, 59	RES,MF,28.7K,+-1%,0.125W,100PPM	235176	91637	CMF-55 2872F T-1	2	
R 37, 54, 67,	RES,CF,1M,+-5%,0.25W	348987	59124	CF1/4 105J	4	
R 69		348987				
R 43	RES,MF,16.2K,+-1%,0.125W,100PPM	226233	91637	CMF-55 1622F T-1	1	
R 48	RES,MF,154K,+-1%,0.125W,100PPM	289447	91637	CMF-55 1543F T-1	1	
R 51, 90	RES,MF,1K,+-1%,0.125W,100PPM	168229	91637	CMF-55 1001F T-1	2	
R 52	RES,CF,8.2K,+-5%,0.25W	441675	59124	CF1/4 822J	1	
R 56	RES,MF,332K,+-1%,0.125W,100PPM	289504	91637	CMF-55 3323F T-1	1	
R 60	RES,CF,9.1K,+-5%,0.25W	441691	59124	CF1/4 912J	1	
R 61, 80	RES,CF,47K,+-5%,0.25W	348896	59124	CF1/4 473J	2	
R 64	RES,MF,604K,+-1%,0.125W,100PPM	235374	89536	235374	1	
R 65	RES,MF,301K,+-1%,0.125W,100PPM	289488	91637	CMF-55 3013F T-1	1	
R 66	RES,CF,18K,+-5%,0.25W	348862	59124	CF1/4 183J	1	
R 68	RES,CF,5.1K,+-5%,0.25W	368712	59124	CF1/4 512J	1	
R 70, 73, 87	RES,MF,75K,+-1%,0.125W,100PPM	291443	91637	CMF-55 7502F T-1	3	
R 71, 72	RES,MF,23.7K,+-1%,0.125W,100PPM	188367	89536	188367	2	
R 75	RES,CF,39K,+-5%,0.25W	442400	59124	CF1/4 393J	1	
R 76, 85	RES,MF,2K,+-1%,0.125W,100PPM	235226	91637	CMF-55 2001F T-1	2	
R 77	RES,MF,42.2K,+-1%,0.125W,100PPM	221655	91637	CMF-55 4222F T-1	1	
R 78	RES,MF,43.2K,+-1%,0.125W,100PPM	272153	91637	CMF-55 4323F T-1	1	
R 79, 88, 89	RES,MF,30.1K,+-1%,0.125W,100PPM	168286	91637	CMF-55 3012F T-1	3	
R 81,113	RES,MF,61.9K,+-1%,0.125W,100PPM	237230	91637	CMF-55 6192F T-1	2	
R 82	RES,MF,46.4K,+-1%,0.125W,100PPM	188375	91637	CMF-55 4642F T-1	1	
R 83	RES,CC,6.2M,+-5%,0.25W	221960	01121	CB6255	1	
R 84	RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF-55 1003F T-1	1	
R 86	RES,CF,2K,+-5%,0.25W	441469	59124	CF1/4 202J	1	
R 91	RES,MF,619K,+-1%,0.125W,100PPM	288639	89536	288639	1	
R 92	RES,MF,6.81K,+-1%,0.125W,100PPM	268417	89536	268417	1	
R 93, 94	RES,MF,6.04K,+-0.1%,0.125W,25PPM	512301	89536	512301	2	
R 96, 97	RES,MF,49.9K,+-1%,0.125W,100PPM	268821	91637	CMF-55 4992F T-1	2	
R 98,109	RES,MF,10,+-1%,0.125W,100PPM	268789	91637	CMF-55 10R0F T-1	2	
R 99,103,110	RES,VAR,CERM,1K,+-20%,0.5W	267856	80294	3009P-EH1-102	3	
R 100,108	RES,VAR,CERM,20K,+-20%,0.5W	267898	80294	3009P-EH1-203	2	
R 101	RES,VAR,CERM,100K,+-10%,0.5W	288308	80294	3386S-1-104	1	
R 102,104	RES,MF,24.9,+-1%,0.125W,100PPM	296657	91637	CMF-55 24R9F T-1	2	
R 105,107	RES,MF,36.5K,+-1%,0.125W,100PPM	235309	91637	CMF-55 3652F T-1	2	
R 106	RES,MF,348K,+-1%,0.125W,100PPM	289512	89536	289512	1	
R 111	RES,MF,2.8K,+-1%,0.125W,100PPM	325670	91637	CMF-55 2801F T-1	1	
R 114,115,500	ZENER REFERENCE SET	646539	89536	646539	3	

Table 161-3. -161 High Performance A/D Converter PCA (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
R 116		RES,VAR,CERM,500,+-20%,0.5W	267849	80294	3009P-EH1-501	1	
R 117,123		RES,CF,1K,+-5%,0.25W	343426	59124	CF1/4 102J	2	
S 1		SWITCH,ROTARY,1 POLE,16 POS,1 THUMB	615096	89536	615096	1	
T 1		INVERTER TRANSFORMER	580407	89536	580407	1	
TP 1, 2, 4,		TERM,FASTON,TAB,.110,SOLDER	512889	00779	62395-1	30	
TP 5, 14, 19-			512889				
TP 22, 30- 44,			512889				
TP 46- 51			512889				
U 1	*	IC,REGULATING PULSE WIDTH MODULATOR	454678	27014	LM3524N	1	
U 2	*	IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	27014	DS1692J	1	
U 3	*	IC,BPLR,DIFFERENTIAL LINE RECEIVER	586073	27014	DS7820AJ	1	
U 4	*	ISOLATOR,OPTO,HI-SPEED,DUAL	429894	28480	HCPL-2531	1	
U 5, 34	*	ISOLATOR,OPTO,HI-SPEED,8 PIN DIP	354164	47379	6N135	2	
U 6, 7, 9,	*	IC,CMOS,QUAD D LATCH,+EDG TRG,W/RESET	412742	27014	MM74C173NorJ	4	
U 14	*		412742				
U 8, 16, 25,	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	408773	27014	MM80C95N	5	
U 29, 37	*		408773				
U 10	*	IC,CMOS,8 BIT MICROCOMPUTER,6MHZ	817239	89536	817239	1	
U 11	*	IC,CMOS,BCD-DEC & BIN-OCTAL DCDR	473769	27014	4028BPC	1	
U 12	*	IC,CMOS,DUAL D F/F,+EDG TRG W/SET&RST	536433	04713	MC14013BCP	1	
U 13	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	27014	CD4001BCN	1	
U 15	*	IC,COMPARATOR,DUAL,LO-PWR,8 PIN DIP	478354	01295	LM393P	1	
U 17	*	IC,CMOS,UNIV ASYNC RECEIVR/TRANSMITER	453464	34371	HD3-6402C-9	1	
U 18	*	IC,LSTTL,QUAD 2 INPUT XOR GATE	605626	01295	SN54LS86J	1	
U 19, 23	*	IC,LSTTL,DUAL JK F/F,+EDG TRG,W/CLR	605634	04713	SN54LS107AJ	2	
U 20	*	IC,LSTTL,QUAD 2 INPUT NAND GATE	605600	27014	DM54LS00J	1	
U 21, 22	*	IC,CMOS,8STAGE SYNC PRSET DWN BIN CNT	508689	89536	508689	2	
U 24	*	IC, 1.22V,100 PPM T.C.,BANDGAP REF	452771	24355	AD589KH	1	
U 26	*	E PROM SET, HIGH PERF. A/D	655555	89536	655555	1	
U 27, 28	*	IC,256 X 4 STAT RAM	605238	34371	HM3-6561-9	2	
U 30	*	IC,CMOS,7STAGE RIPPLE CARRY BIN CNTR	412965	89536	412965	1	
U 31	*	IC,CMOS,DUAL JK F/F,+EDG TRIG	355230	27014	CD4027BCN	1	
U 32	*	IC,CMOS,DUAL SYNC BINRY UP CNTR	355164	04713	MC14520BCP	1	
U 33, 49	*	IC,OP AMP,DUAL,INDUSTRIAL TEMP RANGE	605550	89536	605550	2	
U 35	*	IC, 2.5 V,40 PPM T.C.,BANDGAP REF	472845	04713	MC1403U	1	
U 36	*	IC,LSTTL,OCTAL D F/F,+EDG TRG	473223	01295	SN74LS374N	1	
U 38, 40	*	IC,CMOS,HEX INVERTER	404681	04713	MC14069UBCP	2	
U 39	*	IC,LSTTL,QUAD 2 INPUT OR GATE	605618	27014	DM54LS32J	1	
U 41	*	IC,CMOS,QUAD 2 INPUT AND GATE	408401	04713	MC14081BCP	1	
U 42	*	IC,COMPARATOR,CERAMIC,8 PIN DIP	605592	89536	605592	1	
U 43, 44	*	IC,OP AMP,DUAL,JFET INPUT,8 PIN DIP	605576	89536	605576	2	
U 45, 47	*	IC,COMPARATOR,QUAD,14 PIN DIP	605584	27014	LM139AJ	2	
U 46	*	IC,OP AMP,JFET INPUT,8 PIN DIP	605568	89536	605568	1	
U 48, 50- 52	*	IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980	06665	OP-07DP	4	
VR 2	*	ZENER,TRANS SUPPRESSOR,6V	508655	11961	1N5908	1	
VR 3, 4	*	ZENER,UNCOMP,6.2V,5%,20.0MA,0.4W	325811	04713	1N753A	2	
W 1, 2		JUMPER,REC,2 POS,.100CTR,.025 SQ POST	530253	00779	530153-2	2	
XU 10, 17		SOCKET,IC,40 PIN	429282	00779	2-640379-1	2	
XU 26		SOCKET,IC,24 PIN	376236	00779	2-640361-1	1	
XU 27, 28		SOCKET,IC,18 PIN	418228	95146	218AG-39D	2	
XZ 7		SOCKET,IC,16 PIN	276535	00779	2-640358-1	1	
Y 1		CRYSTAL,6MHZ,+-0.01%,HC-18/U	461665	89536	461665	1	
Z 1, 13		RES,CERM,SIP,6 PIN,5 RES,10K,+-2%	500876	91637	CSC06A-01-103G	2	
Z 2, 10		RES,CERM,SIP,10 PIN,5 RES,10K,+-2%	529990	91637	CSC10A-03-103G	2	
Z 3, 4		RES,CERM,SIP,10 PIN,9 RES,10K,+-2%	414003	91637	CSC10A-01-103G	2	
Z 5		RES,CERM,SIP,8 PIN,4 RES,10K,+-2%	513309	91637	CSC08A-03-103G	1	
Z 6		RES,CERM,SIP,8 PIN,7 RES,10K,+-2%	412924	91637	CSC08A-01-103G	1	
Z 7		RES,CERM,DIP,16 PIN,8 RES,33,+-5%	413575	91637	MDP16-01-330J	1	
Z 8		RES,CERM,DIP,16 PIN,8 RES,47K,+-5%	381996	89536	381996	1	
Z 9		RES,CERM,DIP,16 PIN,8 RES,100K,+-5%	380618	91637	MDP16-03-104J	1	
Z 11	*	RES NET ASSY TESTED	705509	89536	705509	1	
Z 12	*	RES NET ASSY TESTED	705558	89536	705558	1	

An * in 'S' column indicates a static-sensitive part.

DESCRIPTION

The -162 Thermocouple/DC Volts Scanner (shown in Figure 162-1) is a plug-in, 1 uV, 20-channel dry-reed relay scanner.

This scanner operates as a self-calibrating analog data multiplexer, linking the A/D Converter to external measurement points. One to five scanners may be installed with each A/D Converter installed in a Computer Front End system.
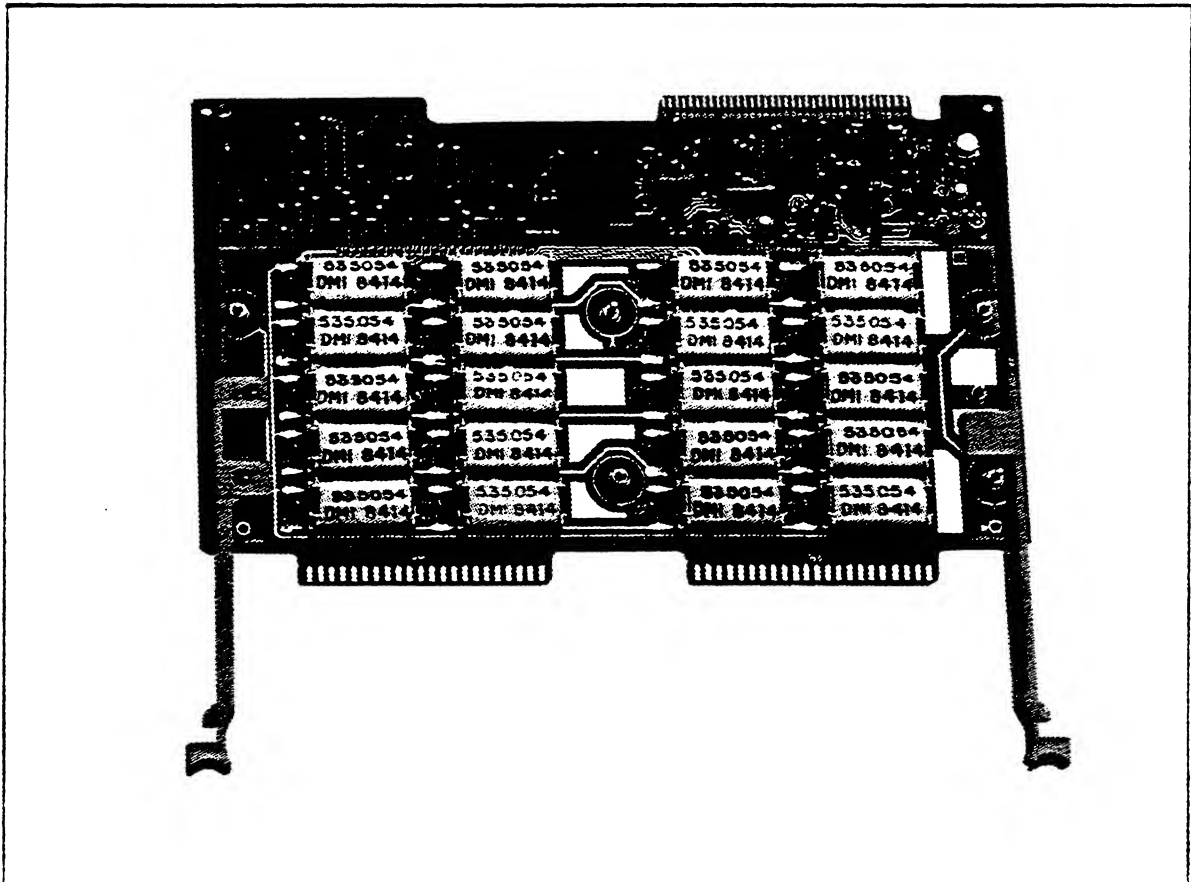
Figure 162-1. Thermocouple/DC Volts Scanner

Each channel of the scanner provides a High, a Low, and a Shield input

which can be accessed through a connector option plugged onto the scanner's two 44-pin card-edge connectors. The scanner accepts only dc voltage inputs, but several different connector options are available to convert various analog measurements into dc voltages. The following connector options are available connector.

o   -160 AC Voltage Input Connector

o   -171 Current Input Connector

o   -175 Isothermal Input Connector

o   -176 Voltage Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Thermocouple/DC Volts Scanner theory of operation, performance tests, parts list, and schematic diagrams.

Installation, operating, and system configuration instructions are located in the Helios I System Manual. Option specifications are located in the appendices to this manual and the System Manual.

The test equipment required to perform the procedures in this subsection is listed in Table 162-1.

An overall summary of test equipment is given in Table 2-2 in Section 2 of this manual.

THEORY OF OPERATION

The Thermocouple/DC Volts Scanner theory of operation includes a functional description of the Thermocouple/DC Volts Scanner, a block diagram analysis (which describes how each major circuit block on the assembly works), and a circuit analysis of each block.

Block diagrams and simplified schematics are included with the text. A parts lists and a schematic diagram for the Thermocouple/DC Volts Scanner can be found at the end of this option subsection.

Overall Functional Description

The Thermocouple/DC Volts Scanner is a reed-relay multiplexer and programmable gain amplifier that allows the A/D Converter access to 20 dc volt or thermocouple input measurement channels.

Gain and zero adjustments need not be made to the scanner amplifier. The A/D directly measures the offset and true gain of each scanner and compensates for those errors during measurements of user inputs.

Table 162-1. Required Test Equipment for -162

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	+/- 31.3 mV +/- 20 uV +2.048V +/- 50 uV -2.048V +/- 2 uV of +2.048 500 mV +/- 20 uV 6.2V +/- 155 uV 6.8V +/- 0.1V 5.0V +/- 100 uV 7.9V +/- 200 uV *63V +/- 800 uV 1.008V +/- 40 uV	Fluke 343 *63V output used only for one optional test.
100:1 Divider	+/- 0.005%	Fluke Y2022
Calibration/ Extender Fixture	NA	Fluke Accessory Part No. 648741 (no substitute)
Digital Multi- Meter (DMM)	+/- 10V +/- 0.06V 0V +/- 1 uV (differential)	Fluke 8505A
Resistor	1 kilohm +/- 5%	Fluke Part No. 108597
Resistor	10 kilohm +/- 5%	Fluke Part No. 109165
High Performance A/D Converter	NA	Fluke Option -161 (no substitute)
Isothermal In- put Connector	NA	Fluke Option -175 (no substitute)
Voltage Input Connector	NA	Fluke Option -176 (no substitute)

Various operating modes of the scanner are listed in Table 162-2. The A/D measures the scanner output for all modes but Discharge, Open Thermocouple Test, and De-Select modes. The user's measurement inputs, channels 0 to 19, are accessed during the Measure modes. The remaining scanner modes are used for the zero and gain correction functions which are transparent to the user.

Table 162-2. Scanner Operating Modes

MODE	OPERATION
De-Select	De-energizes the reed switches of the input channel previously measured, and waits for them to open.
Discharge	Shorts the input filter capacitor to ground in preparation for the next measurement.
Open T/C Test	Bleeds a small current into the input filter capacitor and changes the range to 512 mV. The A/D determines whether the connected thermocouple circuit has low enough resistance.
64 mV Zero	The A/D measures the scanner offset with the input to the scanner buffer amplifier grounded through a 39 kilohm resistor on the 64-mV range.
8V Zero	The A/D measures the scanner offset with the input grounded through a 78 kilohm resistor on the 8V range.
50 mV Cal	The A/D measures the scanner output when a 50-mV input supplied by the A/D Converter is applied on the 64-mV range.
500 mV Cal	The A/D measures the scanner output when a 500-mV input supplied by the A/D Converter is applied on the 512-mV range.
6.2V Cal	The A/D measures the scanner output with an A/D supplied 6.2V input on the 8V range.

Table 162-2. Scanner Operating Modes (cont.)

MODE	OPERATION
64 mV Measure	The A/D measures the scanner output with an input channel selected on the 64-mV range. Channel reeds are closed.
512 mV Measure	The A/D measures the scanner output with the scanner on the 512-mV range with an input channel selected. Channel reeds are closed.
8V Measure	The A/D measures an input channel on the 8V scanner range. Selected channel reeds are closed.
64V Measure	The A/D measures the scanner output with an input channel selected on the 64-mV range. Channel reeds are closed.
Ref Junction	The A/D measures the output voltage of the semiconductor sensor embedded in the isothermal input connector (when one is used) with the scanner on the 512mV range. This measurement is required for thermocouple temperature measurements.

Scanner operation can be divided into two measurement sequences: calibration and scanning. Calibration is performed every ten minutes at the direction of the mainframe and involves measuring the gains of the scanner amplifier on three ranges. Scanning, the normal mode of operation, occurs when the A/D Converter is instructed to measure user input channels. Both sequences are controlled by the A/D Converter through the scanner control lines: Scanner Selects (SCNS[1:5](H)), Channel Selects (CHS[0:4]), Range Selects (RNG[0:1](L)), Calibrate (CAL(H)), Discharge Inhibit (DSCHG INH(H)), Reference Junction Enable, Open Thermocouple Test (OTC EN(H)), and Zero (ZERO(H)).

Detailed Circuit Description

The amplifier composed of U11, Q14, Q15, Q16, CR28, R19, and R20 has gains of 4 and 32. Amplifier gain is selected by U10 under control of signal RNG0(L). Components Z5, Q3, Q4, and K20 work as a switchable high-impedance, 125-to-1 ratio, voltage divider. The divider is enabled by the RNG1(L) control signal. To remove high-frequency noise, input signals are filtered by C15 in conjunction with R10 or the output resistance of Z5, depending on the state of the RNG1(L) signal.

The full-scale output of the amplifier is bipolar 2.048V. The two amplifier gains in combination with the high-impedance divider yields four dc volt ranges: 64 mV, 512 mV, 8V, and 64V full scale.

Decoders U2 and U8, gating in U3, and comparators U7, U9, and U10 select one of several inputs to the amplifier. The A/D Converter selects an input.

Reed switches provide high voltage isolation from channel to channel and scanner to scanner. Each input channel is connected to the scanner amplifier circuitry by three reed switches closed by a single drive coil (K0 through K19). One of the 20 channels is selected when decoder U2 is presented with an input from 0 through 9 (decimal) via signals CHS[0:3](H) and SCNS1(H) is true. The selected channel is in the lower group (K0 through K9) if CHS4 is low and in the higher group (K10 through K19) if CHS4 is high. Decoder U2 does not activate any outputs (and, therefore, no channels are selected) when its inputs are outside the 0 through 9 range (decimal).

Components U3 and U4 identify the presence of the scanner and its type to the A/D Converter. If the scanner select control line SCNS1 is asserted, the Thermocouple/DC Volt scanner pulls SCN[0:2](H) lines low when a -175 Isothermal Input Connector is installed on the scanner and pulls only SCN0(H) and SCN1(H) low if a -176 Voltage Input Connector or -171 Current Input Connector or no input connector is installed.

GENERAL MAINTENANCE

The Thermocouple/DC Volts Scanner normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface.

If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

Three performance tests, which can be performed separately or together, verify that the Thermocouple/DC Volts Scanner is operational and meets its accuracy specifications.

NOTE

Since the Thermocouple/DC Volts Scanner must be used with the -161 A/D Converter, the A/D Converter must be tested and calibrated first.

The three performance tests are:

o   Channel Integrity Test

o   Accuracy Verification Test:

o   Open Thermocouple Response Test:

These performance tests verify that the Thermocouple/DC Volts Scanner meets specified accuracy tolerances on all channels. If the scanner fails one of the tests, it must be repaired or replaced since there are no calibration adjustments on the scanner.

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

Channel Integrity Test

The Channel Integrity Test verifies that each scanner channel is functional. Use the following procedure to perform this test:

1.   Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2.   Set the address switch on an -161 A/D Converter to 0, and install it in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner to be tested in the option slot just below the A/D Converter.

3.   Connect a pair of test leads to the HI and LO terminals of Channel 0 of a -175 or -176 input connector. Install the input connector on the scanner.

4.   Reconnect the ac line cord to the Front End, and switch the power ON.

5.   Connect the calibrator output to the input connector test leads.

6.   Set the calibrator output to 7.9000V dc.

7.   Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

     Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM  <CR>

DEF CHAN(0..19)=DVIN,MAX=7.9  <CR>

FORMAT=DECIMAL  <CR>

SEND CHAN(0)  <CR>
```

The value returned for the selected channel should be 7.9V +/- 0.002V.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
100   GOSUB 300
120   PRINT #1,"def chan(0..19)=dvin,max=7.9"
125   GOSUB 300
130   PRINT #1,"format=decimal"
140   GOSUB 300
150   REM make measurement and read in response
160   PRINT #1,"send chan(0..19)"
170   FOR I=0 TO 19
180   INPUT #1,M$
190   PRINT "chan";I;"=";
```

```
200   PRINT USING "###.###";VAL(M$);
210   PRINT " Volts DC"
220   NEXT I
230   END
300   REM wait for message accepted prompt
310   INPUT #1,A$        .
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for a 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1
50    OPEN "KB1:"AS OLD FILE 2
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"count=off"
110   GOSUB 300
120   PRINT #1,"def chan(0..19)=dvin,max=7.9"
130   GOSUB 300
140   PRINT #1,"format=decimal"
150   GOSUB 300
160   REM make measurement and read in response
170   I=0
180   FOR R=1 TO 10
190   FOR C=0 TO 1
200   PRINT #1,"send chan(";I;")"
210   INPUT #2,M$
220   PRINT TAB(35*C);"chan";I;"=";
230   PRINT USING "S###.###",VAL(M$);
240   PRINT " Volts DC"
250   I=I+1
260   NEXT C
270   NEXT R
280   END
300   REM wait for message accepted prompt
310   INPUT #2,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

The value returned for the selected channel should be 7.9V
+/- 0.002V.

8. Set the calibrator output to zero. Move the input connector test
    leads to the terminals for the next channel to be tested.

9. Repeat steps 6 through 8 for each remaining voltage input channel (1 through 19).

   If the Terminal Mode is being used, do so by substituting the appropriate channel number in the SEND CHAN command.

10. This completes the Channel Integrity Test.

Continue with the Accuracy Verification Test if you are performing a complete verification of the scanner and you have not already performed the test as part of the performance testing of the A/D Converter.

Accuracy Verification Test

The Accuracy Verification Test checks scanner accuracy against specifications. Because all voltage readings returned by the Front End are dependent upon the accuracy of the A/D Converter, the A/D Converter must be calibrated before performing this test.

Use the following procedure to perform the Accuracy Verification Test:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to 0, and install the A/D Converter in the top option slot of the Front End.

   Install a scanner in the slot just below the A/D Converter.

3. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or on a -175 Isothermal Input Connector.

   Install the connector on the scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the calibrator output to the input of the 100:1 Voltage Divider. Connect the output of the divider to the scanner input connector test leads.

6. Set the calibrator to output 6.2000V.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

    MODE=TERM <CR>

    DEF CHAN(0)=DVIN, MAX=0.062

    FORMAT=DECIMAL <CR>

    SEND CHAN(0) <CR>

The returned value for channel 0 should be 62 mV +/- 0.014 mV.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a DC voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM Set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0)=dvin,max=0.062"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0)"
170  INPUT #1,M$
180  PRINT "chan 0 = ";
190  PRINT USING "##.######";VAL(M$)
200  PRINT " Volts DC"
210  END
```

```
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for a 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1
50   OPEN "KB1:"AS OLD FILE 2
60   PRINT #1,CHR$(3);
70   REM set up Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0)=dvin,max=0.062"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0)"
170  INPUT #2,M$
180  PRINT "chan 0 = ";
190  PRINT USING "S##.######",VAL(M$);
200  PRINT " Volts DC"
210  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The returned value for channel 0 should be 62 mV +/- 0.014 mV.

8. Change to the 512 mV voltage range by redefining channel 0.

    To redefine channel 0 in the Terminal Mode, send the command:

        DEF CHAN(0)=DVIN, MAX=0.5 <CR>

    If you are using Computer Mode, do so by changing the BASIC
    statement in line 120 to:

        PRINT #1,"def chan(0)=dvin, max=0.5"

9. Set the calibrator to 0. Remove the 100:1 divider, and connect the
    calibrator output directly to the connector test leads on channel
    0.

)

10. Set the calibrator to output 500 mV.

11. Take a measurement on channel 0. It should return a value of 500 mV +/- 0.1 mV.

   In the Terminal Mode, the measurement can be taken by sending the following command:

   SEND CHAN(0) <CR>

   In Computer Mode, run the program as modified in step 8.

12. Change to the 8V range by redefining channel 0.

   In the Terminal Mode, send the command:

   DEF CHAN(0)=DVIN, MAX=7.9 <CR>

   In the Computer Mode, change the BASIC program statement in line 120 appropriately.

13. Set the calibrator output to 7.9000V.

14. Take another measurement as described in step 11. Verify that the returned value is 7.9V +/- 0.002V.

15. Change to the 64V range by redefining channel 0.

   To redefine channel 0 in the Terminal Mode, send the command:

   DEF CHAN(0)=DVIN, MAX=63 <CR>

   In the Computer Mode, change the BASIC program statement in line 120 appropriately.

16. Set the calibrator output to 63.000V.

17. Take a measurement on channel 0.

   The returned value should be 63V +/- 0.02V.

18. The Accuracy Verification Test is now complete.

Continue with the Open Thermocouple Response Test if you are performing a complete verification test of the scanner and you have not already performed the test in the A/D Converter performance test section.

Open Thermocouple Response Test

The Open Thermocouple Response Test checks whether the A/D Converter and scanner respond with an open thermocouple indication when presented with an open thermocouple channel input.

NOTE

This test is also one of the A/D Converter
performance tests. It is repeated here because
both the scanner and the A/D contain the circuitry
which senses open thermocouple conditions. The
test need not be -repeated if it was performed
previously.

Use the following procedure to perform the Open Thermocouple Response
Test:

1. Switch OFF power to the Front End. Disconnect the ac line power
    cord and all other high voltage inputs.

2. Set the A/D Converter address switch to "0" and install the A/D in
    the top option slot of the Computer Front End. Install the
    Thermocouple/DC Volts Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on the
    -175 Isothermal Input Connector. Install the connector on the
    scanner.

4. Reconnect the ac line cord to the Front End and switch the power
    ON.

5. Connect the test leads from the Isothermal Input Connector to a 1
    kilohm resistor.

6. Program the Front End using either a terminal or a computer. (You
    can also run a terminal emulation program to use a computer
    behaving as a terminal.) For ease of testing, a terminal is the
    recommended host.

    Use PROCEDURE A or PROCEDURE B, depending on whether performance
    testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected
host, send the following commands to the Front End.

        MODE=TERM <CR>

        DEF CHAN(0)=TC,TYPE=JNBS <CR>

        TUNIT=CELSIUS <CR>

        FORMAT=DECIMAL <CR>

        SEND CHAN(0) <CR>

The value returned for channel 0 should be equal to the ambient
temperature +/- 2 degrees Celsius.

PROCEDURE B. COMPUTER MODE

The following BASIC programming examples will cause the Front End
to take a thermocouple measurement on channel 0. One program was
written for an IBM PC and one for a Fluke 1722A Instrument
Controller.

NOTE

These programs are offered as examples. If you do
not have an IBM PC or a Fluke 1722A Instrument
Controller, enter a program that will run on your
host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
110 PRINT #1,"def chan(0)=tc,type=jnbs"
120 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 PRINT #1,"tunit=celsius"
160 GOSUB 300
170 REM make measurement and read in response
180 PRINT #1,"send chan(0)"
190 INPUT #1,M$
200 PRINT M$
210 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1
50  OPEN "KB1:"AS OLD FILE 2
60  PRINT #1,CHR$(3);
70  REM set up computer Front End
```

```
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0)=tc,type=jnbs"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  PRINT #1,"tunit=celsius"
170  GOSUB 300
180  REM make measurement and read in response
190  PRINT #1,"send chan(0)"
200  INPUT #2,M$
210  PRINT M$
220  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value returned for channel 0 should be equal to the ambient
temperature +/- 2 degrees Celsius.

7. Replace the 1-kilohm resistor with a 10-kilohm resistor to simulate
    a high resistance or open thermocouple.

8. Request a measurement and verify that the returned value is:

        9.99999E+37

9. Perform PROCEDURE 9A or PROCEDURE 9B as appropriate.

PROCEDURE 9A. TERMINAL MODE

Send the following command to inspect the fault condition:

        LIST ERROR <CR>

The following error message should be displayed

        chan(0)-open tc

meaning that a temperature measurement was attempted with a damaged
or improperly connected thermocouple.

PROCEDURE 9B. COMPUTER MODE

Run one of the following BASIC programs (or a similar one
appropriate to your host).

Program for an IBM PC:

```
10  CLS
20  REM send the fault condition
30  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40  PRINT #1,"list error"
50  INPUT #1,N
60  PRINT N
70  IF N=0 THEN 120
80  FOR I=1 TO N
90  LINE INPUT #1,E$
100 PRINT E$
110 NEXT I
120 END
```

Program for a 1722A:

```
10  PRINT CHR$(27);"[2J";
20  REM send the fault condition
30  PRINT #1,"list error"
40  INPUT #2,N
50  PRINT N
60  IF N=0 THEN 110
70  FOR I=1 TO N
80  INPUT LINE #2,E$
90  PRINT E$
100 NEXT I
110 END
```

The displayed response should be:

```
        1
      0,16
```

The top number, "1", indicates that one error was logged. The lower set of numbers, "0,16", indicates that error 16 was logged on channel 0.

Error number 16, "?Open TC," means that a temperature measurement was attempted with a damaged or improperly connected thermocouple.

10. Disconnect the 10-kilohm resistor and the test leads from the Isothermal Input Connector.

Performance testing of the Thermocouple/DC Volts Scanner is complete.

CALIBRATION

No calibration is required for the Thermocouple/DC Volts Scanner.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the -162 Thermocouple/DC Volts Scanner is given in Table 162-3.

For parts ordering information, see Section 6 of this manual.

Figure 162-2 is a schematic diagram of the Thermocouple/DC Volts Scanner.

```
TABLE 162-3. -162 THERMOCOUPLE/DC VOLTS SCANNER PCA
(SEE FIGURE 162-2.)
                                                                              N
REFERENCE                                  FLUKE   MFRS    MANUFACTURERS    R  O
DESIGNATOR                                 STOCK   SPLY    PART NUMBER   TOT S  T
A->NUMERICS--->  S -----------DESCRIPTION----------- --NO-- CODE- --OR GENERIC TYPE-- QTY -Q -E
---------------  ------------------------------------ ------ ----- ------------------- --- -- --
C    1-  8, 16     CAP,CER,0.22UF,+-20%,50V,Z5U      519157 51406 RPE111Z5U224M50V     9
C    9, 13         CAP,CER,1.0UF,+-20%,50V,Z5U       436782 72982 8131-050-601-105M    2
C   10             CAP,CER,33PF,+-2%,100V,COG        513226 51406 RPE121               1
C   11, 12         CAP,CER,1800PF,+-5%,50V,COG       528547 89536 528547               2
C   15             CAP,POLYPR,6800PF,+-5%,50V        706564 89536 706564               1
C   17             CAP,TA,10UF,+-20%,15V             193623 56289 196D106X0015A1       1
CR   1-  6,  8-  • DIODE,SI,BV= 75.0V,IO=150MA,500 MW 203323 07910 1N4448             26
CR  27            •                                  203323
CR   7            • DIODE,SI,2 PELLET,BV= 20.0V,400 MW 375477 09214 MPD200            1  6
H    1             WASHER,FLAT S STEEL,#4,0.032 THK  146225 89536 146225               1
H    2             SCREW,MACH,PHP,S STL,4-40X3/4      681973 89536 681973               1
H    3             NUT,HEX,S,STL,4-40                147611 89536 147611               1
J    1- 22         SOCKET,SINGLE,PWB,FOR 0.025 PIN   267476 00779 85861-2             22
J    1- 22         PIN,SINGLE,PWB,0.025 SQ           649681 00779 3-87022-2           22
K    0- 19         RELAY COIL ASSY                   777623 89536 777623              20
K   20             RELAY,REED,1 FORM A,5VDC          404061 71707 CR-3201-5-710        1
K   21             RELAY,REED,1 FORM A,5VDC          520247 71707 UF-40115             1
MP   1             SPACER,REED                       617415 89536 617415               1
MP   2             BAG,SHIELDING,TRANSPARENT,12"X16" 680983 89536 680983               1
MP   3             PCB,GUARD,TOP                     583294 89536 583294               1
MP   4             SPACER,SWAGED,RND,BRASS,0.125IDX0.187 436675 89536 436675           5  3
MP   5             SPACER,SWGD,RND,BRASS,0.150IDX0.125 335075 89536 335075             1
MP   6             PCB COIL                          580647 89536 580647               1
Q    1-  4,  6-  • TRANSISTOR,SI,N-JFET,TO-92        376475 15818 U2810J              13  1
Q   12, 15, 16    •                                  376475
Q    5            • TRANSISTOR,SI,N-JFET,DUAL,TO-71  419283 89536 419283               1  1
Q   13            • TRANSISTOR,SI,PNP,SMALL SIGNAL   418707 04713 MPS56562             1  3
Q   14            • TRANSISTOR,SI,N-JFET,DUAL,TO-71  461772 17856 DN1675               1  1
Q   17            • TRANSISTOR,SI,N-JFET,REMOTE CUTOFF 429977 89536 429977            1  1
Q   28            • DIODE,SI,N-JFET,CURRENT REG,IF=0.43MA 393454 89536 393454         1  1
R    1,  2         RES,CF,20K,+-5%,0.25W             441477 80031 CR251-4-5P20K        2
R    3,  6-  9,    RES,CF,100K,+-5%,0.25W            348920 80031 CR251-4-5P100K       7
R   14, 16                                           348920
R    4, 21         RES,CF,100,+-5%,0.25W             348771 80031 CR251-4-5P100E       2
R    5, 33, 36,    RES,CC,150,+-5%,0.25W             147934 01121 CB1515              21
R   37, 40, 41,                                      147934
R   44, 45, 48,                                      147934
R   50, 52, 53,                                      147934
R   55, 58, 60,                                      147934
R   61, 63, 66,                                      147934
R   68, 69, 71                                       147934
R   10             RESISTOR,TIMOX,39K,+-5%,2W        615435 89536 615435               1
R   11, 13, 15,    RES,CF,10K,+-5%,0.25W             348839 80031 CR251-4-5P10K        4
R   32                                               348839
R   17             RES,CF,470,+-5%,0.25W             343434 80031 CR251-4-5P470E       1
R   18, 23         RES,CF,39K,+-5%,0.25W             442400 80031 CR251-4-5P39K        2
R   19, 20         RES,MF,15.4K,+-0.1%,0.125W,25PPM  340604 91637 CMF551542F           2
R   31             RES,CF,1K,+-5%,0.25W              343426 80031 CR251-4-5P1K          1
R   34, 35, 38,    RES,CC,470,+-5%,0.25W             147983 01121 CB4715              20
R   39, 42, 43,                                      147983
R   46, 47, 49,                                      147983
R   51, 54, 56,                                      147983
R   57, 59, 62,                                      147983
R   64, 65, 67,                                      147983
R   70, 72                                           147983
S    1- 60         SWITCH,REED,1 FORM A,10VA,36AT    647578 89536 647578              60
U    1,  5,  6,  • IC,CMOS,DUAL 2 IN NAND DRVR W/OPN DRN 604207 02735 CD40107BE      11  1
U   12- 19        •                                  604207
U    2            • IC,CMOS,BCD-DEC & BINRY-OCTAL DECODER 650689 89536 650689         1  1
U    3            • IC,CMOS,QUAD 2 INPUT NOR GATE    355172 02735 CD4001AE             1  1
U    4            • IC,CMOS,HEX BUFFER W/3-STATE OUTPUT 407759 12040 MM80C97N         1  1
U    7,  9, 10    • IC,COMPARATOR,QUAD,CERAMIC,14 PIN DIP 605584 89536 605584         3  1
U    8            • IC,CMOS,DUAL 1 OF 4 DECODER      584987 04713 MC14555BP            1  1
U   11            • IC,OP AMP,GENERAL PURPOSE,TO-78 CASE 418368 89536 418368          1  1
Z    1,  3         RES,NET,SIP,8 PIN,7 RES,100K,+-2% 412908 89536 412908              2
Z    2             RES,NET,SIP,6 PIN,5 RES,100K,+-2% 412726 89536 412726              1
Z    4            • GAIN RES NET ASSY TESTED-2280A   611186 89536 611186              1
Z    5            • INPUT DIVIDER RESNET ASSY TESTED2286A 616011 89536 616011         1
```

DESCRIPTION

The -163 RTD/Resistance Scanner (shown in Figure 163-1) multiplexes 20 input channels, with 3 or 4 poles per channel, and makes each channel available in sequence to the A/D Converter.

The -177 RTD/Resistance Input Connector is used with the RTD/Resistance Scanner to provide connection terminals for the external wiring.
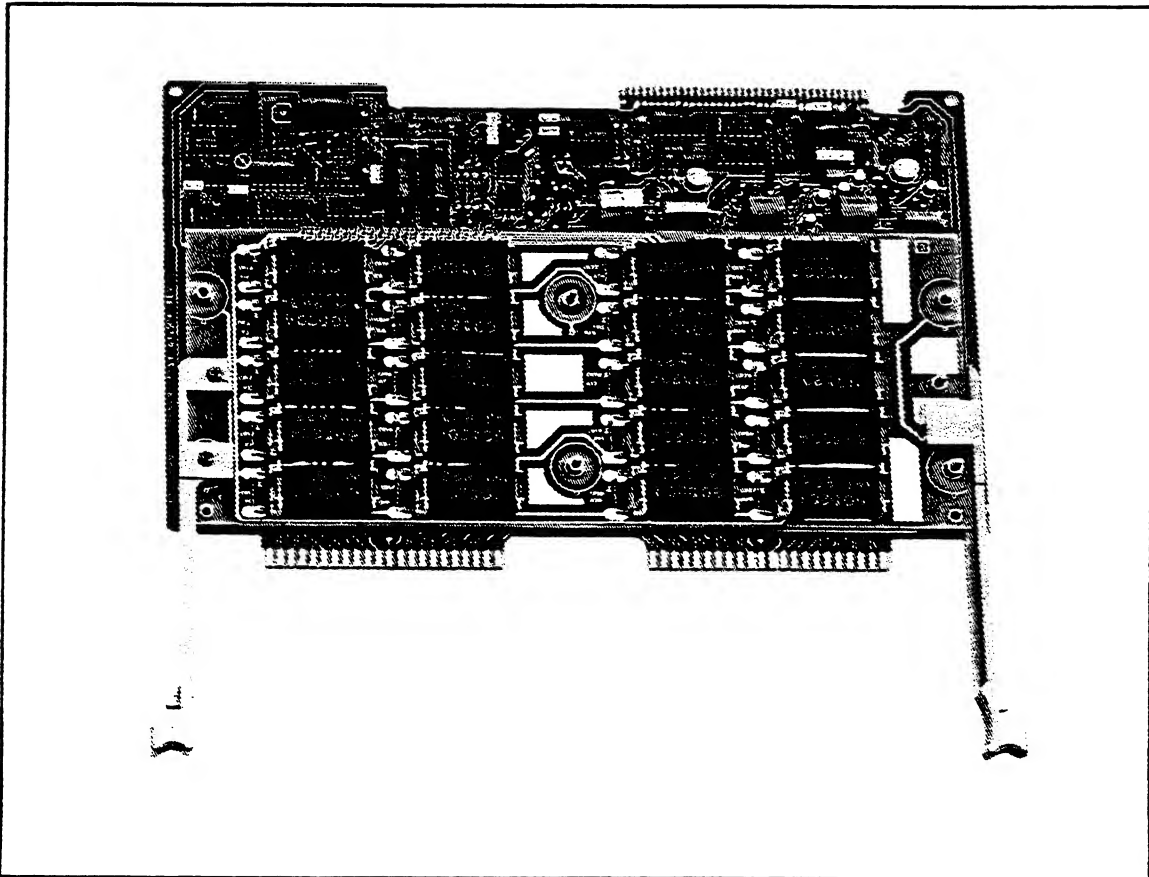
Figure 163-1. The RTD/Resistance Scanner

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: RTD/Resistance Scanner theory of operation, performance tests, a parts list, and schematic diagrams.

Installation, operating, and system configuration instructions are in the Helios I System Manual. Option specifications are in the appendices to this manual and the System Manual.

Test equipment required for the procedures in this subsection is listed in Table 163-1. See Table 2-2 for an overall summary of test equipment.

Table 163-1. Required Test Equipment for -163

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
A/D Converter	NA	Fluke Option -161 rev E-2, F-1, G-1, H-1, or newer (no substitute)
RTD/Ohms Input Connector	NA	Fluke Option -177 (no substitute)
Resistors R1 through R3	100 ohm, 0.01%, 5 ppm/C hermetically sealed wirewound	Fluke Part No. 491720
Resistors R4, R5	100 ohm, 0.1%, T9 metal film	Fluke Part No. 357400
Toggle Switch	Single-pole, double-throw (SPDT)	Fluke Part No. 493825

THEORY OF OPERATION

The RTD/Resistance Scanner theory of operation includes: a functional description of the RTD/Resistance Scanner, a block diagram (Figure 163-2) analysis, and a detailed circuit circuit analysis of each block on the RTD/Resistance Scanner assembly.

Where necessary, block diagrams and simplified schematics are included with the text. Schematic diagrams for the RTD/Resistance Scanner are at the end of this option subsection.
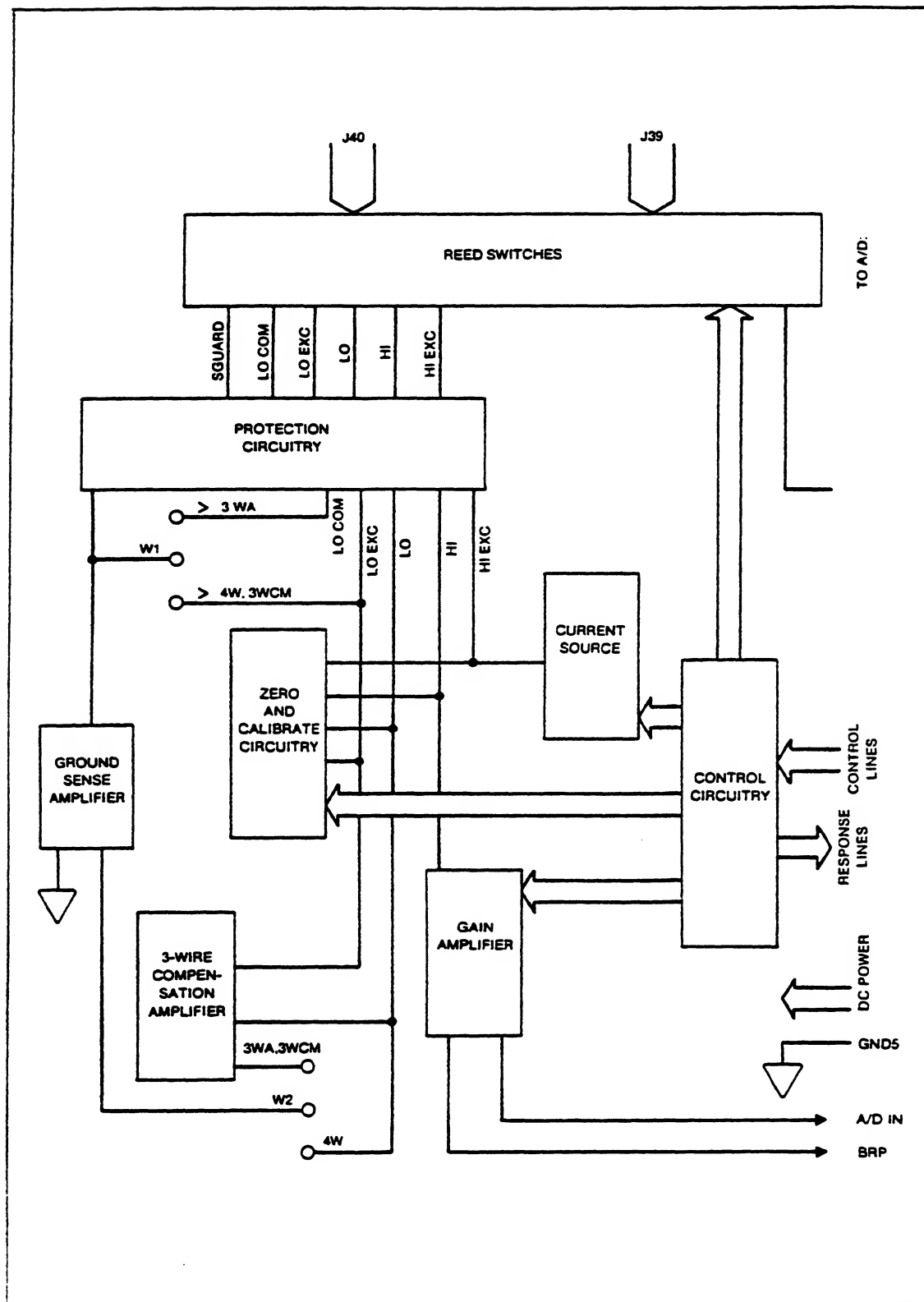
Figure 163-2. RTD/Resistance Scanner Block Diagram

Overall Functional Description

The RTD/Resistance Scanner and the -177 RTD/Resistance Input Connector work with a -161 A/D Converter to measure resistance inputs with high accuracy and stability. Power for the scanner is supplied as +/- 10V and + 5V from the A/D Converter.

When instructed by the Controller, the RTD/Resistance Scanner selects and conditions one of 20 channels. A resistance to be measured is selected by reed relays and excited by one of two current levels, and one of two amplifier gains is chosen to condition the resulting voltage in preparation for conversion by the A/D Converter.

Compensation is provided for the two 3-wire modes of operation: 3-Wire Accurate (3WA) and 3-Wire with Common Mode (3WCM). Reed resistance errors are eliminated in the 4-Wire (4W) and 3WA modes. Auto-zero and auto-calibration features are incorporated for use by the A/D Converter.

Three measurement ranges, 256 ohms, 2048 ohms, and 64 kilohms full scale are included in the RTD/Ohms Scanner. One operation mode is selected by two jumpers for all 20 channels on each scanner. Ranges for each channel are selected by the user.

Detailed Circuit Description

REED SWITCHES

Reed switches provide high voltage isolation from channel to channel and scanner to scanner.

Each input channel is connected to scanner circuitry by four reed switches driven by a single drive coil. An additional individual reed relay, K21 or K22, pulls in to provide a common current-return path for the decade of channels in which the channel selected resides, eliminating reed resistance errors in the (3WA) mode of operation. One more individual reed relay, K20, connects the A/D Converter guard to a LO line whenever the scanner is selected by the A/D Converter.

Figure 163-3 shows one channel of reed switches, with the components used in other channels listed in parentheses. The reeds for one channel, Sxx-A,B,C,D, are pulled in by the corresponding drive coil Kxx, while K21 or K22 is pulled in at the same time to provide the LO COM return for a decade of channels in the 3WA mode of operation. Relay K20 is pulled in whenever the scanner is selected by the A/D Converter, connecting the A/D guard to LO of the resistance being measured through K20 and the LO COM or LO EXC reed switches.

PROTECTION CIRCUITRY

To protect scanner and A/D circuitry, channel inputs are isolated, energy limited, and diode clamped.

Figure 163-4 shows a schematic diagram of the protection circuitry.
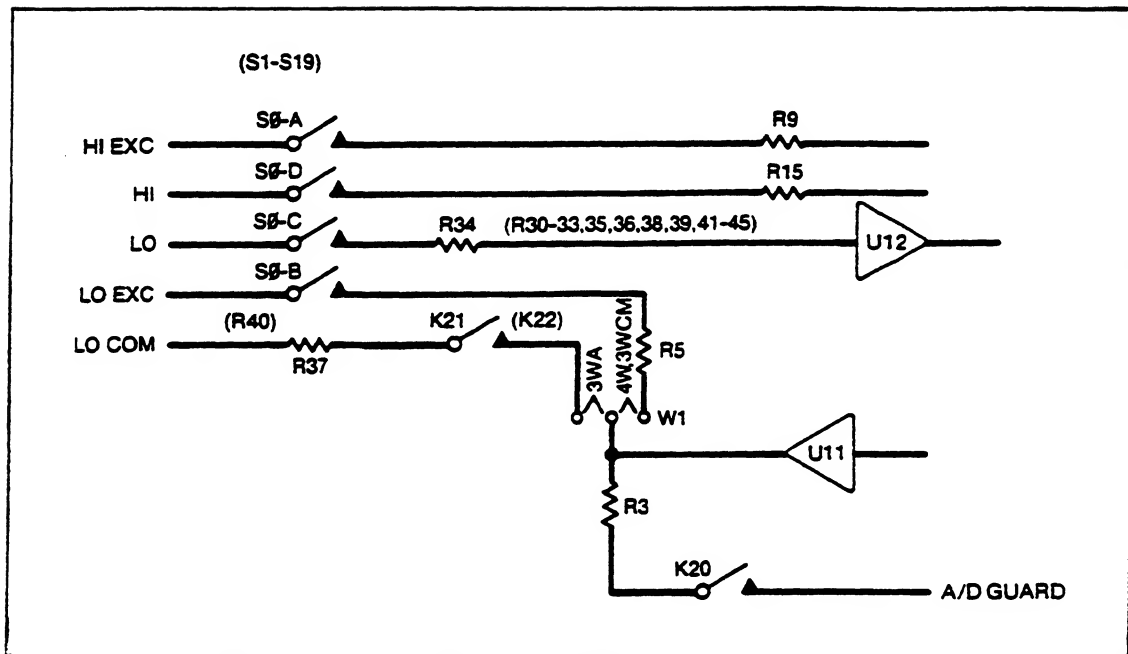
Figure 163-3. One Reed-Switch Channel
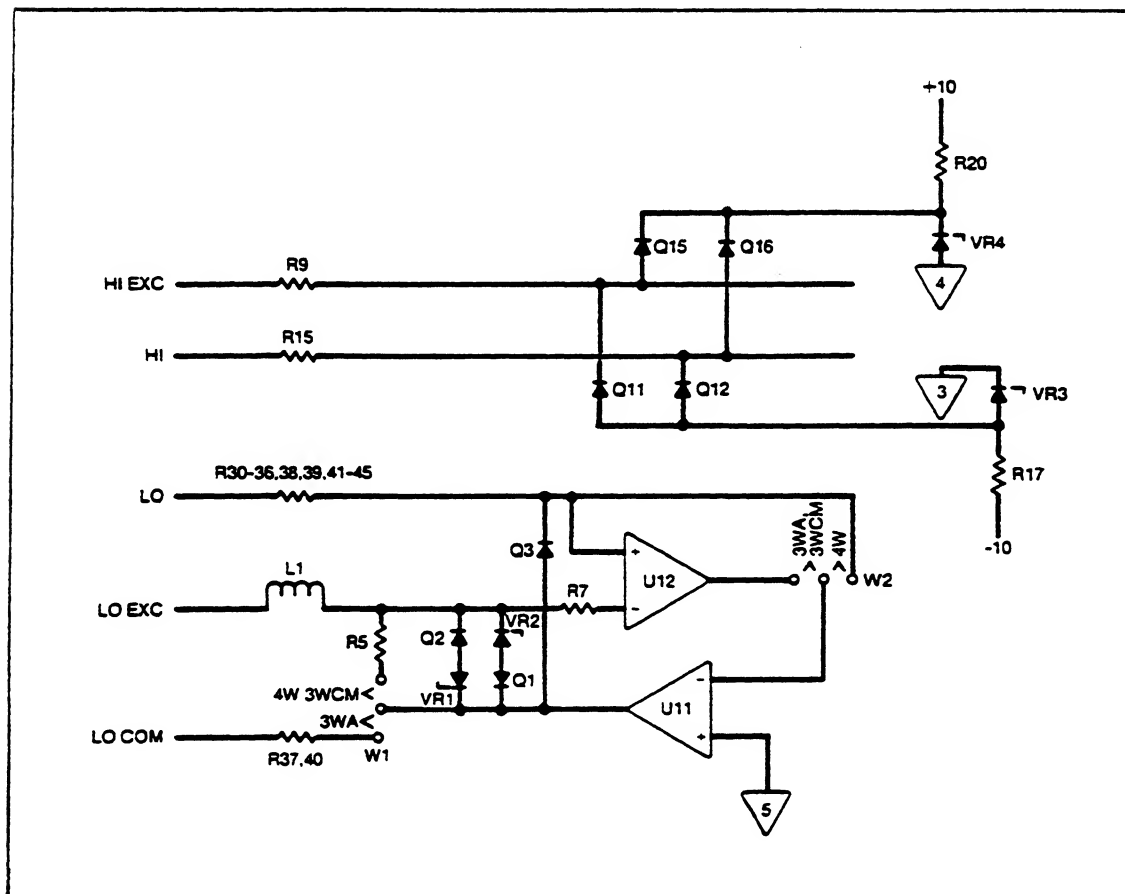
Figure 163-4. Protection Circuitry

In Figure 163-4, input terminals are clamped to defined voltages through series resistances. A positive clamp voltage of approximately 3 to 5V is provided by VR4, which is biased by R20, while a negative voltage is provided by VR3, which is biased by R17. R9 dissipates overvoltages to the HI EXC terminal in combination with Q15 and VR4 or Q11 and VR3. Both Q15 and Q11 are reverse biased in normal operation. R15 dissipates overvoltages to HI, passing current through Q16 or Q12, which are reverse biased in normal operation. LO terminals are protected by series resistors R30 through 36, R38, R39, and R41 through 45, and by the input protection diodes of U11 and U12, and Q3. L1 slows down fast transient voltages entering LO EXC terminals, while VR1, VR2, Q1, and Q2 clamp LO EXC to LO COM through W1 in the 3WA mode of operation, with R37 and R40 limiting current and dissipating power. R7 also serves to limit LO EXC current into the input of U12.

GAIN AMPLIFIER

The gain amplifier circuit filters and amplifies the signal on the HI terminal. The gain is set to 8 for the 250-ohm range, and unity is set for the other two ranges. One input filter is used with the high ohms range, while the other is used with the 256-ohm and 2048-ohm ranges. The scanner output is enabled whenever the scanner is selected by the A/D Converter.
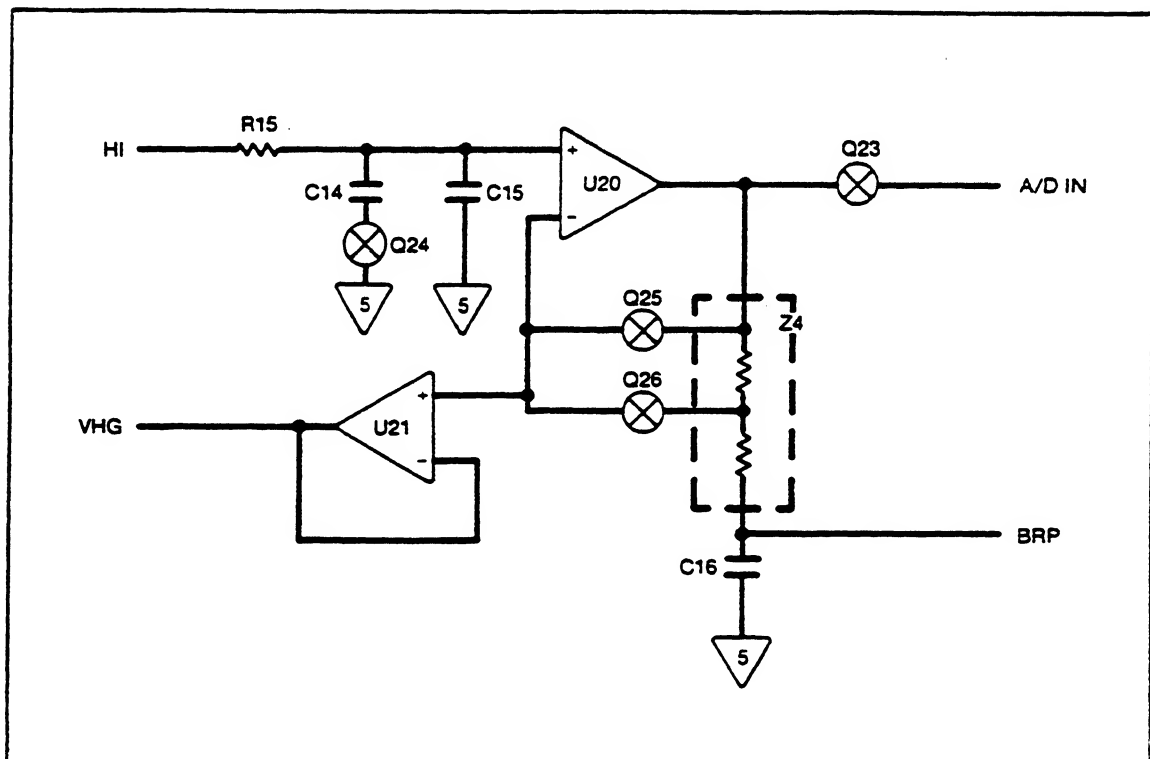
Figure 163-5. Gain Amplifier

Figure 163-5 is a schematic diagram of the gain amplifier. Two voltage gains are provided by U20 and associated components, with the output to the A/D Converter enabled by turning on Q23. Q25 sets the gain at unity, while Q26 and Z4 set the gain at 8.00. BRP, which stands for beta

return path, returns currents flowing through Z4 to the A/D Converter, and C16 shunts ac signals on BRP to Ground 5. The resistance being measured plus R15 and C15 provide noise filtering of the HI input for the 64-kilohm range, with C14 switched in parallel with C15 by Q24 for the two lower resistance ranges. The VHG amplifier, U21, drives guard traces surrounding all HI circuit traces to prevent leakage under high humidity conditions.

CURRENT SOURCE

Two zener-referenced current outputs can be set by the current source circuitry, with one of the two selected at all times. The 256-ohm and 2048-ohm ranges use the 1.0 mA output, and the 64-kilohm range uses the 32-uA output. The 32-uA output can be set to another value by changing a precision resistor if a larger full scale value than 64-kilohms is desired.
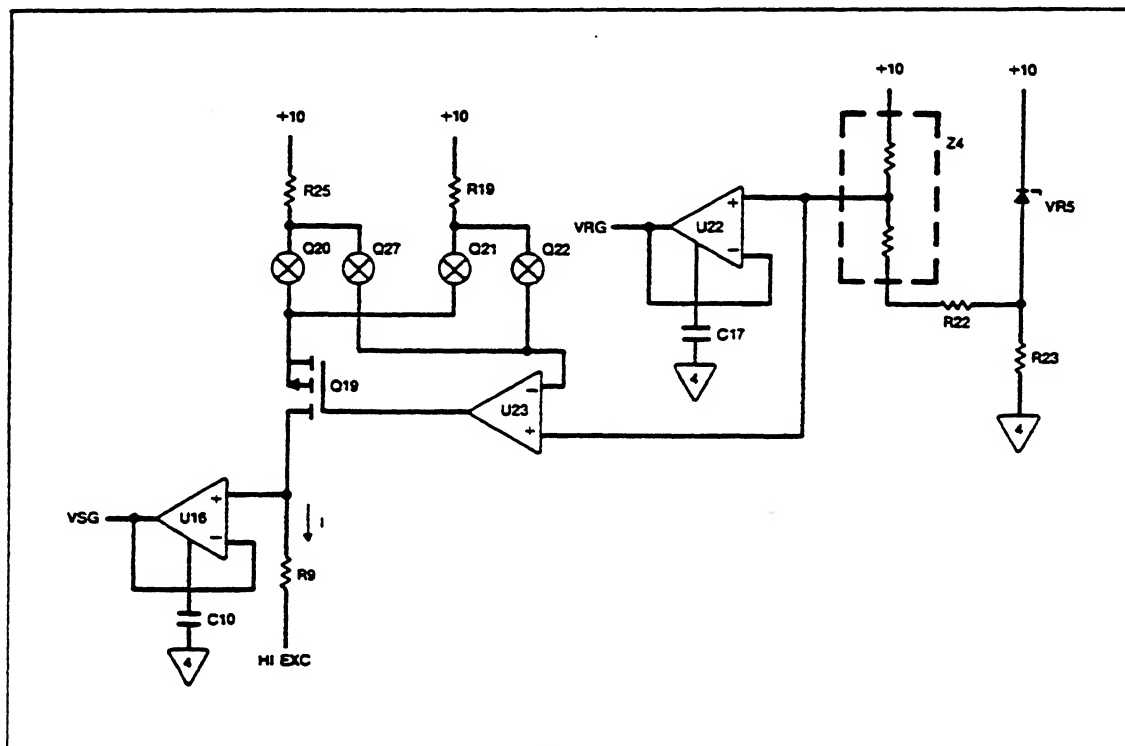
Figure 163-6. Current Source

A simplified schematic of the current source is shown in Figure 163-6. As can be seen in the schematic, the current source is centered around a stable voltage reference and precision resistances. A potential 6.2V below the +10V rail is generated by the zener reference set composed of VR5, R23, and R22, and this is then divided down to 5.00V below the rail by Z4. Range selection is provided by Q20 and Q27 (which select R25 for a 1 mA current) and Q21 and Q22, which select R19 for a 32 uA (standard) current. U23 compares the voltage across R25 or R19 to the 5V reference and enhances the gate of Q19 by the necessary amount to bring equilibrium to the circuit. Q19 then passes the current through R9 to

the HI EXC reed switches. The VRG amplifier, U22, provides guard drive
to traces that prevent leakage out of or into the circuit nodes that sit
at the +5V potential. The VSG amplifier, U16, provides guard drive to
traces which prevent leakage out of the circuitry at the potential of
the drain of Q19. Capacitors C10 and C17 stabilize U16 and U22
respectively in their unity-gain configuration.

GROUND SENSE AMPLIFIER

The ground sense amplifier sets LO to a potential that allows the A/D
Converter to make readings of HI with respect to ground. In 4-wire mode,
tha amplifier compares LO to the analog ground 5, and in 3WA and 3WCM
modes it compares the output of the 3-wire compensation amplifier to
analog ground. To set LO at the desired voltage level, the amplifier
pulls the necessary current through LO EXC in 4-wire and 3WCM modes, or
LO COM in the 3WA mode.
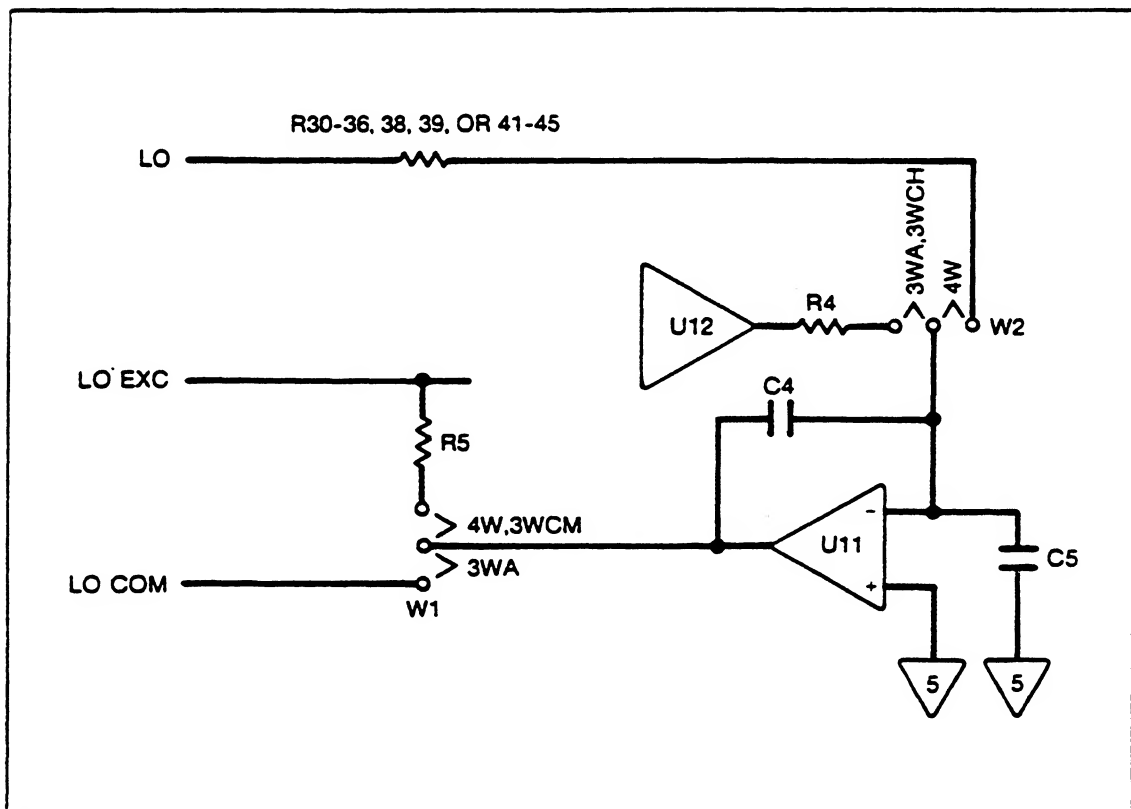
Figure 163-7. Ground Sense Amplifier

Refer to the simplified schematic of teh ground sense amplifier shown in
Figure 163-7. The ground sense amplifier, as part of the measurement
circuit, senses the potential at LO, or the output of U12, and sets it
to analog ground 5 potential, thereby allowing the A/D Converter, which
does not have a differential input, to make measurements with respect to
ground. U11, in response to the inputs, pulls current through R5 and LO
EXC or LO COM, depending on the setting of W1. Capacitor C4 in
combination with R4 or R30 through 36, R38, R39, or R41 through 45 roll
off the gain of U11 to reduce out-of-band noise, and C5 reduces the
noise sensitivity of U11.

3-WIRE COMPENSATION AMPLIFIER

The output of the 3-wire compensation amplifier is selected when W2 is set to the 3WA and 3WCM position. The voltage difference between LO and LO EXC is measured to determine the lead wire voltage drop, and the output of the compensation amplifier is set to that one lead wire drop above the LO potential. The ground sense amplifier sets the output of the compensation amplifier to ground potential, setting LO to one lead wire voltage drop below ground, and thereby compensating for the HI lead wire drop.
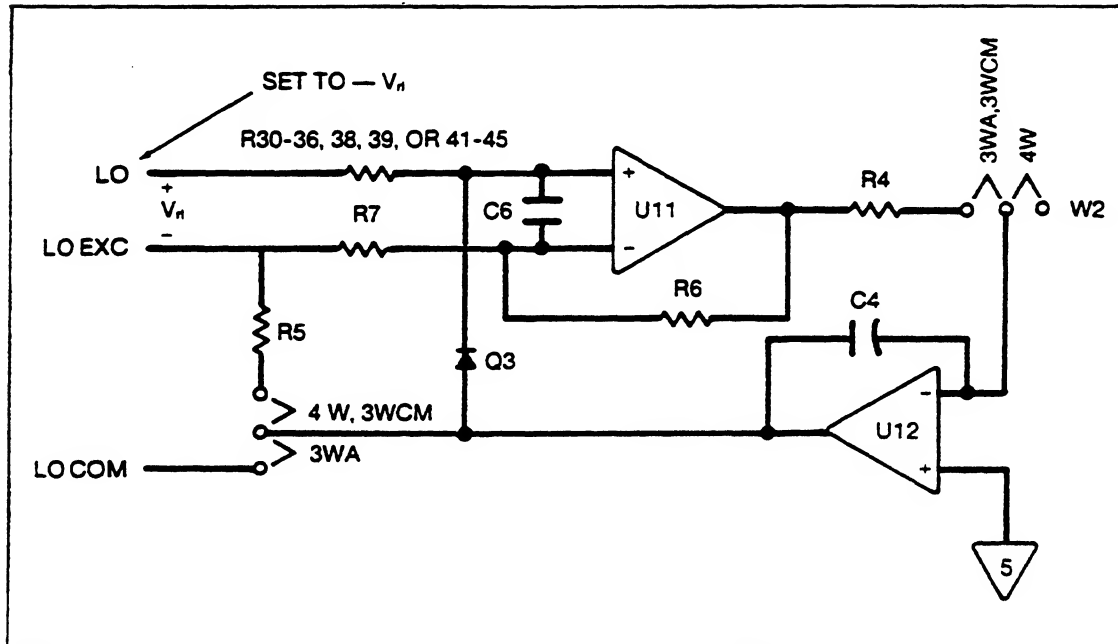
Figure 163-8. 3-Wire Compensation Amplifier

Refer to Figure 163-8, a simplified schematic of the 3-wire compensation amplifier, for the following discussion. In the two 3-wire modes of operation, U12 measures the lead wire voltage drop between LO and LO EXC (Vrl), with R7 and R6 setting the gain at -1, so that the U12 output is +Vrl, or one lead wire drop, above LO. U11 senses this output, and pulls current through LO COM or LO EXC until the U12 output is set at ground potential, thereby setting LO at -Vrl or one lead wire drop below ground to compensate for the lead wire drop in the HI lead. R4 and C4 stabilize the compensation amplifier loop and roll off the gain for frequencies that are not of interest, and the resistors in the LO path plus C6 and R7 reduce the noise sensitivity of U12.

ZERO CIRCUITRY

The zero circuitry, which is enabled by the A/D Converter, configures the scanner so that readings can be made which will allow the A/D Converter to subtract zero errors from all channel measurements. The circuitry is enabled at the start of each scan, giving direct readings of voltage and current offsets on the 256-ohm and 64-kilohm ranges. The 2048-ohm range zero reading is calculated by dividing the 256-ohm range zero reading by 8.
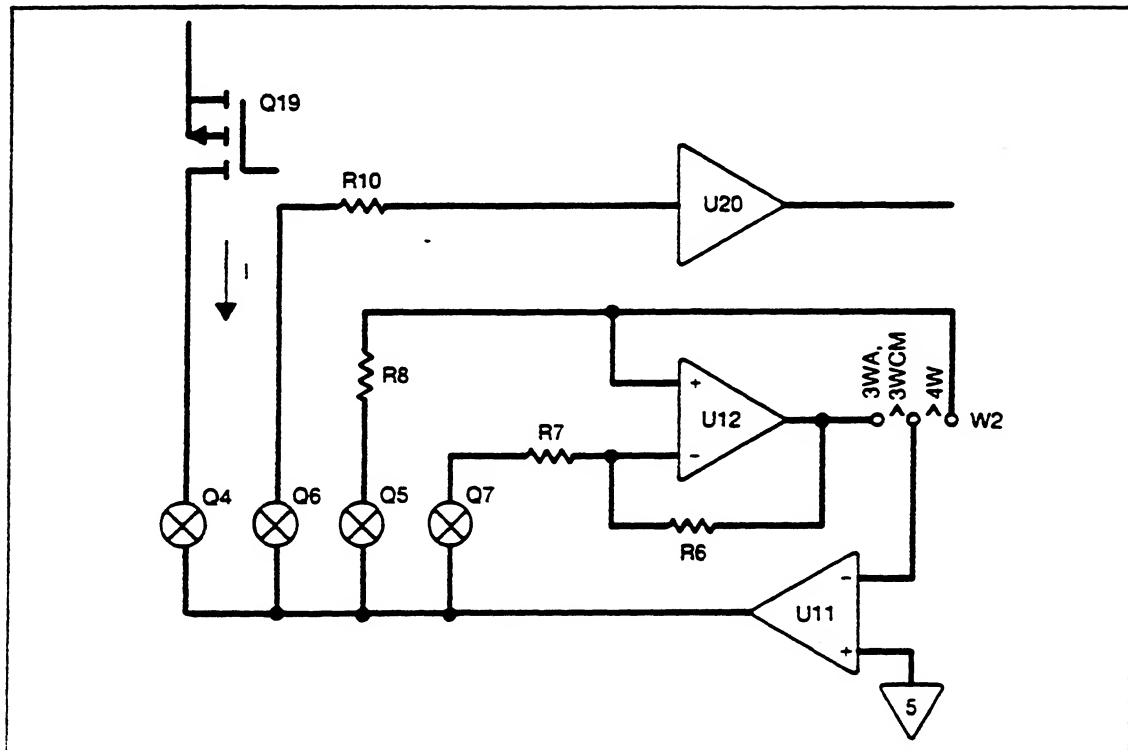
Figure 163-9. Zero Circuitry

Refer to Figure 163-9, a simplified schematic of the zero circuitry, for the following discussion.

To allow the A/D Converter to make zero readings, Q5 and Q7 close the loop around U11 and U12 so that voltage errors appear at the output of U11, and Q6 then connects the U11 output to the gain amplifier, U20. Q4 is turned on to connect the current source to U11 and keep the zero measurements consistent with channel measurements. The resistances of R8 and R10 add to the "on" resistances of Q5 and Q6 to cancel bias current shifts generated by the series resistances present in the HI and LO input lines when making channel readings.

CALIBRATE CIRCUITRY

The calibrate circuitry is enabled by the A/D Converter once every ten minutes (or on command) and the subsequent calibrate readings are used to calculate gain correction factors used by the A/D Converter when making channel readings.

Three precision resistors located on the scanner are measured and used as references for the three ranges. The voltages expected by the 2.048-volt full scale A/D Converter during calibrate are: 1.600V on the 256-ohm range, 2.000V on the 2048-ohm range, and 1.5872V on the 64-kilohm range. If a larger full scale than 64-kilohms is desired, one of the precision reference resistors must be changed.
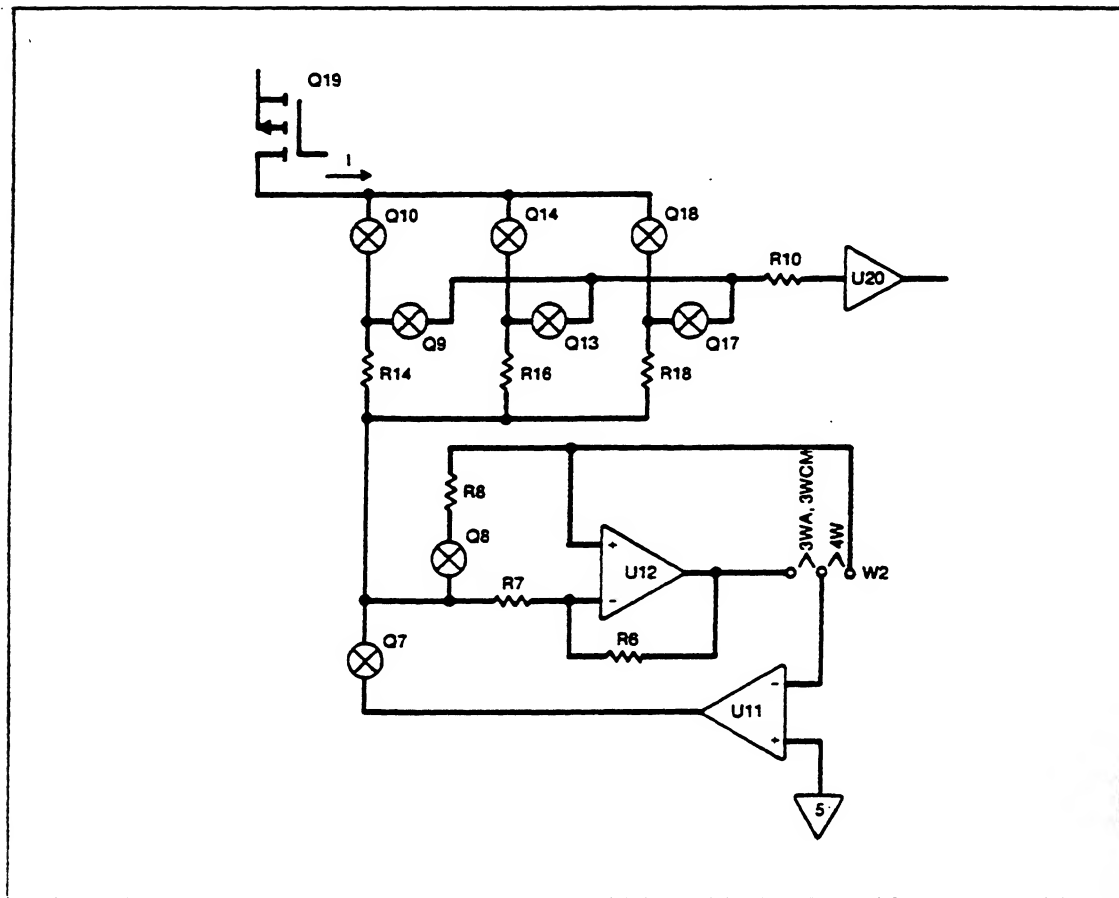
Figure 163-10. Calibrate Circuitry

Figure 163-10 is a simplified schematic of the calibrate circuitry. To close the loop around U11 and U12 in a way that bias current and offset voltage errors are included in the calibrate readings, Q7 and Q8 are turned on. U11 pulls current through Q7, setting the lower ends of R14, R16, and R18 at the proper potential near ground. During a 256-ohm range calibrate, Q10 supplies current to reference resistor R14, and Q9 switches in the gain amplifier, U20, to make a measurement. During a 2048-ohm range calibrate, Q14 supplies current to R16, and Q13 switches in U20, and during a 64-kohm range calibrate, Q18 supplies R18, with Q17 switching in U20. Resistors R8 and R10 are included to cancel the primary shifts in readings made by U11, U12, and U20 bias currents.

CONTROL CIRCUITRY

The control circuitry is a CMOS and open-collector comparator circuitry that decodes the A/D Converter control signals and controls scanner operation. The control circuitry selects and drives the reed coils, turns on zero and calibrate circuitry, sets the gain of the gain amplifier, and sets the output of the current source when directed by the A/D Converter. The control circuitry also sends the proper configuration code back to the A/D Converter, asserts RDY (ready), and turns on the scanner output when the scanner is selected.

Figure 163-11 shows a simplified schematic of the scanner control circuitry.
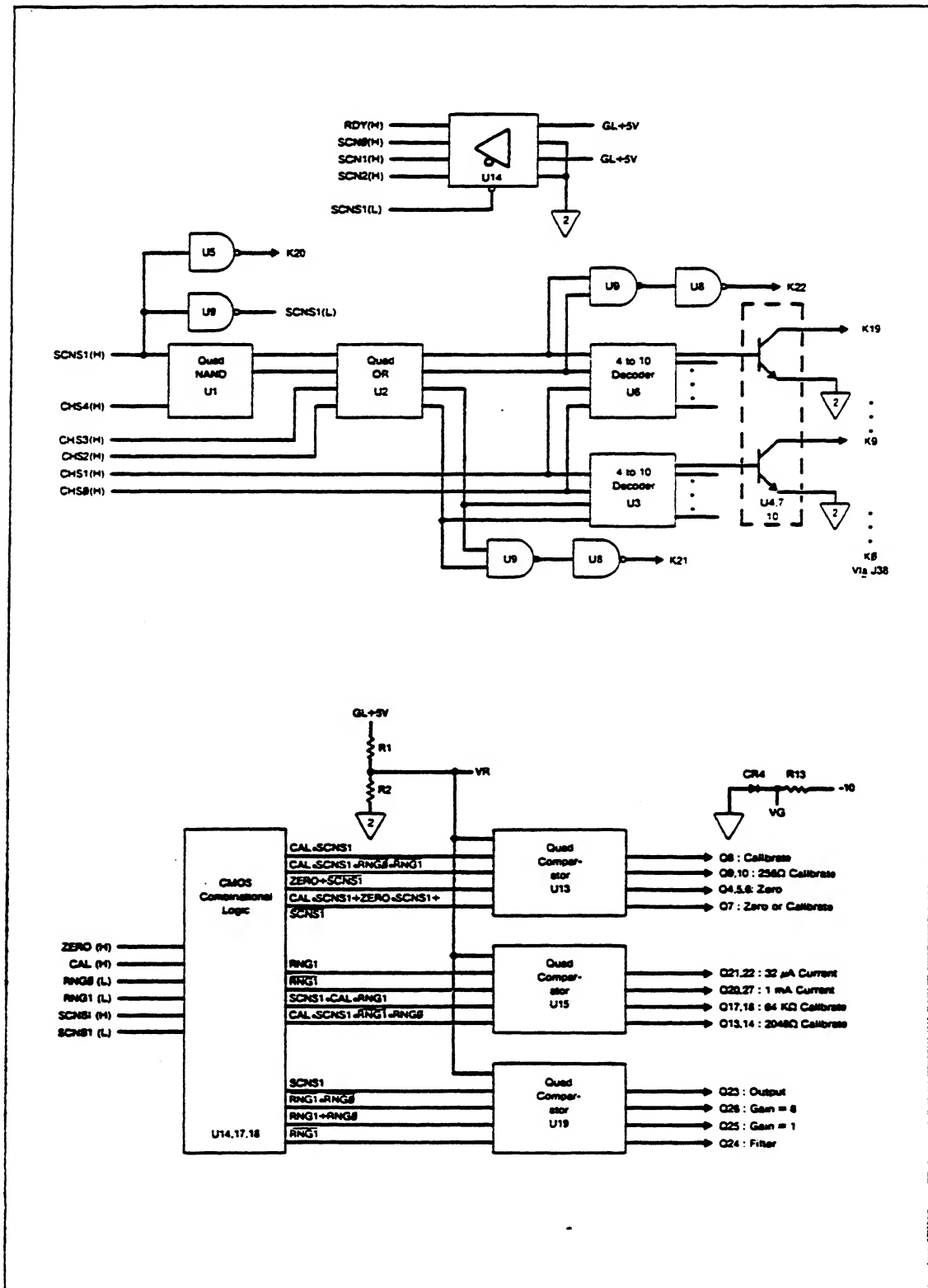
Figure 163-11. Control Circuitry

The first section of control circuitry asserts the RDY(H) and SCN[0:2](H) lines with U14 whenever SCNS1 is asserted by the A/D Converter. This indicates to the A/D Converter that the scanner is ready to make readings and that it is an RTD/Resistance Scanner.

A second section of control circuitry decodes and provides reed relay coil drive. U5 turns on K20 to connect the A/D Guard whenever the scanner is selected by SCNS1. U1 selects the 4-to-10 decoder needed to match the CHS4 line, and locks out the other decoder by asserting the two high bits of the unneeded one. When the scanner is not selected by SCNS1, the two high bits of both U3 and U6 are asserted, preventing both decoders from enabling any of their output lines. U2 passes either the lockout control lines, or the CHS2 and CHS3 channel select lines to U3 and U6. When U3 is selected, one gate of U9 instructs U8 to pull K21 in, completing the LO COM path for channels 0 through 9, while when U6 is selected, U9 has U8 pull K22 in, completing the LO COM path for channels 10 through 19. When a channel is selected by the SCNS1 and CHS[0:4] lines, U3 or U6 drive the base of an NPN transistor residing in arrays U4, U7, or U10, which switches on, driving the proper reed relay coil, and closing the four (A through D) channel reeds.

The third block of scanner control circuitry enables FET transistor switches to select the scanner functions and configurations. Logic ICs U14, U17, and U18 decode five control lines from the A/D; ZERO(H), CAL(H), RNG0(L), RNG1(L), and SCNS1(H), plus SCNS1(L) generated by U9. When SCNS1 is de-asserted and the scanner is not selected, zero mode is configured, while the current source range is set by the RNG1 line. Outputs of the logic gates are sent to comparators U13, U15, and U19 where they are compared to a 2.5V reference generated by R1 and R2. The Boolean expressions are written above each control line leading to the comparators. The comparator outputs then drive the gates of the FET transistors and perform the specific functions listed. All N-channel JFET transistors are pulled up to VG, a voltage set by CR4 and R13, through 100 kilohm pull-up resistors, which are not shown. For example, asserting CAL and SCNS1 causes U13 to turn on Q8, helping to place the scanner in a calibrate configuration.

GENERAL MAINTENANCE

The -163 RTD/Resistance Scanner normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

Six tests are conducted to verify that the RTD/Resistance Scanner is operating properly and meets specifications in all modes and operating ranges. These tests can be used as an initial acceptance test or as a troubleshooting aid. Equipment required to perform the following tests is listed in Table 163-1.

WARNING

THE COMPUTER FRONT END CONTAINS DANGEROUS HIGH
VOLTAGES THAT CAN BE FATAL. ONLY QUALIFIED PERSONNEL
SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF
THE COMPUTER FRONT END AND REMOVE ALL POWER
SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

Performance Test Preparation

Perform the following procedure to prepare for performance testing:

1. Wire the input connector as shown in Figure 163-12, with all
    connections to R1, R2, and R3 made to the resistor leads. (See
    Table 163-1 for resistor specifications.)

2. Switch OFF power to the Front End and disconnect the ac line cord
    and all other high voltage inputs.
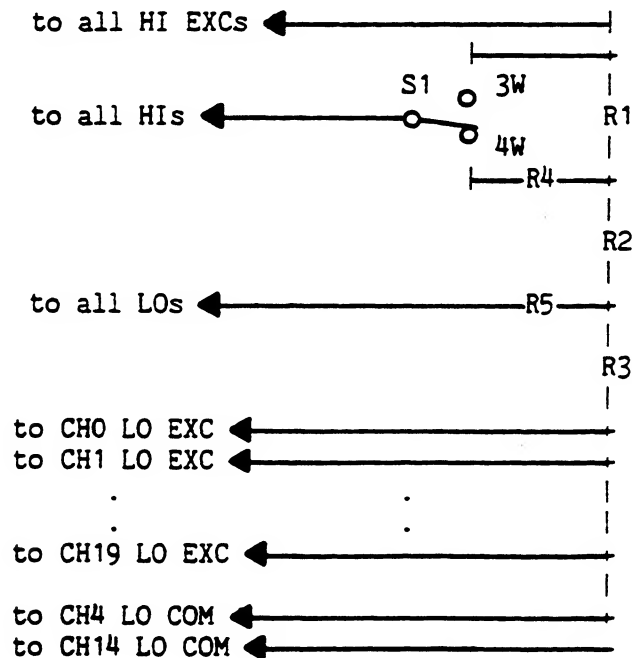
Figure 163-12. Test Input Connector Schematic

3. Set the A/D Converter address switch to "0" and install the A/D
    Converter in the top Computer Front End option slot.

4. Set jumpers W1 and W2 of the RTD/Resistance Scanner for 4W
    operation, and install the scanner in the option slot immediately
    below the A/D Converter. See Figure 163-13.
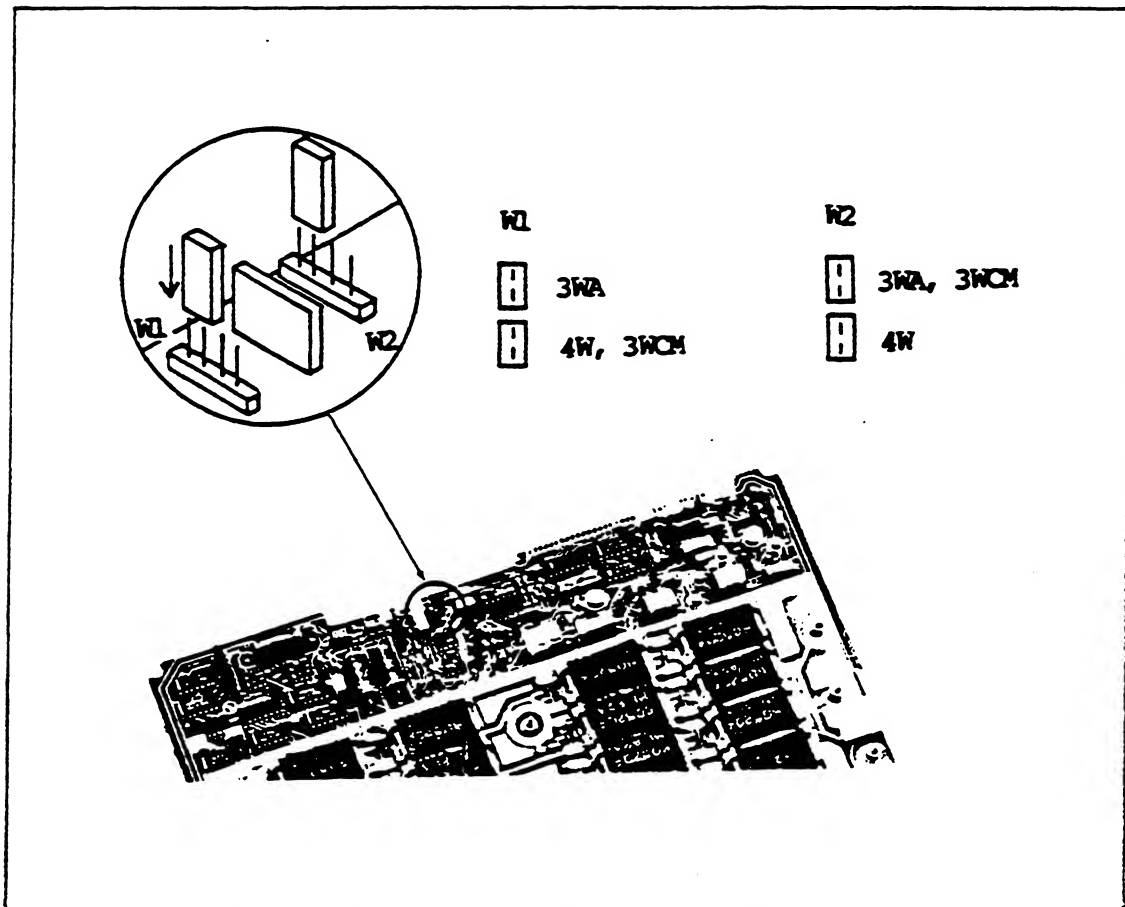
Figure 163-13. W1 and W2 Jumper Settings

5. Set S1 of the Test Input Connector to the 4W position, and install
    the connector on the RTD/Resistance Scanner.

6. Reconnect the ac line cord to the Front End and switch the power
    ON.

Performance Test Procedures

The following six tests will be performed:

o   Serial Link Communication Test

o   256-Ohm Range, 4-Wire Mode Test

o   2048-Ohm Range, 4-Wire Mode Test

o   64-Kilohm Range, 4-Wire Mode Test

o   256-Ohm Range, 3WA Mode Test

o   256-Ohm Range, 3WCM Test

To conduct these tests, the Front End must be programmed using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A (Terminal Mode) or PROCEDURE B (Computer Mode), depending on whether the six performance tests will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, conduct the six performance tests as follows:

SERIAL LINK COMMUNICATION TEST

1. Send the following commands to the Front End:

    MODE=TERM <CR>

    RESET CHAN(0..19) <CR>

    LIST CHAN(0..19) <CR>

2. A listing for each of the 20 designated channels should be returned as follows:

    aichan(0)=R, def=off
              .
              .
              .
    aichan(19)=R, def=off

250-OHM RANGE, 4-WIRE MODE TEST

1. Ensure the RTD/Resistance Scanner's W1 and W2 jumpers are set for 4W operation. See Figure 163-13.

2. Ensure that the Test Input Connector switch S1 is set to 4W.

3. Send the following commands to the Front End:

    FORMAT=DECIMAL <CR>

    DEF CHAN(0..19)=RESIST, MAX=100 <CR>

    SEND CHAN(0..19) <CR>

    The returned channel readings should be between 99.964 and 100.036 ohms.

2048-OHM RANGE, 4-WIRE MODE TEST

1.   Send the following commands to the Front End:

DEF CHAN(0..19)=RESIST, MAX=2000 <CR>

SEND CHAN(0..19) <CR>

2.   The returned channel readings should be between 99.930 and 100.070 ohms.

64K-OHM RANGE, 4-WIRE MODE TEST

1.   Send the following commands to the Front End:

DEF CHAN(0..19)=RESIST, MAX=6000 <CR>

SEND CHAN(0..19) <CR>

2.   The readings should now be between 98.700 and 101.300 ohms.

256-OHM RANGE, 3WA MODE TEST

1.   Switch OFF power to the Front End and remove the RTD/Resistance Scanner and Test Input Connector.

2.   Set the W1 and W2 jumpers of the scanner for 3WA operation. See Figure 163-13.

3.   Set S1 of the Test Input Connector to the 3W position.

4.   Reinstall both the RTD/Resistance Scanner and Test Input Connector in below the A/D Converter. Switch the power ON.

5.   Send the following commands to the Front End:

DEF CHAN(0..19)=RESIST, MAX=100 <CR>

SEND CHAN(0..19) <CR>

The readings should be between 99.743 and 100.257 ohms.

256-OHM RANGE, 3WCM TEST

1.   Switch OFF power to the Front End, and remove the RTD/Resistance Scanner and Test Input Connector.

2.   Set the W1 and W2 jumpers of the scanner for 3WCM operation. See Figure 163-13.

3.   Ensure that S1 of the Test Input Connector is in the 3W position.

4. Reinstall both the RTD/Resistance Scanner and the Test Input
    Connector below the A/D Converter. Switch power ON.

5. Send the following command to the Front End:

    SEND CHAN(0..19) <CR>

    The channel readings should be between 99.150 and 100.850
    ohms.

This completes performance testing in Terminal Mode.

PROCEDURE B. COMPUTER MODE

PROCEDURE B is used for performance testing if a computer (rather than a
terminal) is the selected host.

The BASIC programs in PROCEDURE B cause the Front End to perform the
required tests on selected channel(s). One program was written for an
IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do
not have an IBM PC or a Fluke 1722A Instrument
Controller, enter a program that will run on your
host.

Conduct the six performance tests as follows:

SERIAL LINK COMMUNICATION TEST

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"reset chan(0..19)"
100   GOSUB 300
110   REM obtain hardware configuration
120   PRINT #1,"list chan(0..19)"
130   FOR I=0 TO 20
140   LINE INPUT #1,M$
150   PRINT M$;
160   NEXT I
```

```
200   END
300   REM wait for message accepted prompt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1%
50    OPEN "KB1:"AS OLD FILE 2%
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"reset chan(0..19)"
110   GOSUB 300
120   REM obtain hardware configuration
130   DIM L$(21)
140   PRINT #1,"list chan(0..19)"
150   FOR I%=0 TO 20\INPUT LINE #2,L$(I%)\NEXT I%
160   X%=0
170   PRINT L$(X%)
180   X%=1
190   FOR C%=0 TO 3
200   PRINT TAB(20*C%);L$(X%);\X%=X%+1
210   IF X%>20 THEN 240
220   NEXT C%
230   GOTO 190
240   END
300   REM wait for message accepted prompt
310   INPUT #2,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Verify that a listing for all 20 channels is returned. The number returned on the first line indicates how many channel definitions will follow. Each subsequent line represents a channel definition.

The following should be returned:

```
20
0,1,2,0,0,0
        .
        .
        .
19,1,2,0,0,0
```

256-OHM RANGE, 4-WIRE MODE TEST

1. Ensure the RTD/Resistance Scanner's W1 and W2 jumpers are set for 4W operation. (See Figure 163-13).

2. Ensure that the Test Input Connector switch S1 is set to 4W.

3. The following are sample BASIC programs for the IBM PC and 1722A. Enter and run one of these programs "as is" or make the modifications necessary to run on your host.

Program for IBM PC

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0..19)=resist,max=100"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0..19)"
170  FOR I=0 TO 19
180  INPUT #1,M$
190  PRINT "chan";I;"=";
200  PRINT USING "###.###";VAL(M$);
210  PRINT " ohms"
220  NEXT I
230  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
```

```
 80  PRINT #1,"mode=comp"
 90  GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..19)=resist,max=100"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  DIM M$(20)
180  PRINT #1,"send chan(0..19)"
190  FOR I%=0 TO 19\INPUT #2,M$(I%)\NEXT I%
200  X%=0\I%=0
210  FOR C%=0 TO 1
220  PRINT TAB(35*C%);"chan";I%;"=";
230  PRINT USING "S###.###",VAL(M$(X%));\PRINT" ohms";
240  X%=X%+1\I%=I%+1\IF X%>19 THEN 270
250  NEXT C%
260  GOTO 210
270  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The returned readings should be between 99.964 and 100.036 ohms.

2048-OHM RANGE, 4-WIRE MODE TEST

1. Change the MAX parameter of the DEF CHAN command in the previous program (for the 256-Ohm Range, 4-Wire Mode Test) to 2000.

    The BASIC statement in line 120 should now read:

    PRINT #1,"def chan(0..19)=resist,max=2000"

2. Run the modified program.

    The returned readings should be between 99.930 and 100.070 ohms.

64K-OHM RANGE, 4-WIRE MODE TEST

1. Change the MAX parameter in the DEF CHAN command in the previous program (for the 256-Ohm Range, 4-Wire Mode Test) to 6000.

    The BASIC statement in line 120 should now read:

    PRINT #1,"def chan(0..19)=resist,max=6000"

2. Run the modified program.

The returned readings should be between 98.700 and 101.300 ohms.

256-OHM RANGE, 3WA MODE TEST

1. Switch OFF power to the Front End and remove the RTD/Resistance Scanner and Test Input Connector.

2. Set the W1 and W2 jumpers of the scanner for 3WA operation. See Figure 163-13.

3. Set S1 of the Test Input Connector to the 3W position.

4. Reinstall both the RTD/Resistance Scanner and the Test Input Connector below the A/D. Switch the power ON.

5. Change the MAX parameter of the DEF CHAN command in the previous program (for the 256-Ohm Range, 4-Wire Mode Test) to 100.

The BASIC statement in line 120 should now read:

PRINT #1,"def chan(0..19)=resist,max=100"

6. Run the modified program.

The readings should be between 99.743 and 100.257 ohms.

256-OHM RANGE, 3WCM TEST

1. Switch OFF power to the Front End and remove the RTD/Resistance Scanner and Test Input Connector.

2. Set the W1 and W2 jumpers of the scanner for 3WCM operation. (See Figure 163-13).

3. Ensure that S1 of the Test Input Connector is in the 3W position.

4. Reinstall both the RTD/Resistance Scanner and the Test Input Connector below the A/D Converter. Switch the power ON.

5. Run the program that was run for the 256-Ohm Range, 3WA Mode Test.

The readings returned should be between 99.150 and 100.850 ohms.

This completes performance testing in the Computer Mode.

CALIBRATION

RTD/Resistance Scanner does not require calibration adjustments.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the RTD/Resistance Scanner is given in Table 163-2.

For parts ordering information, see Section 6 of this manual.

Figure 163-14 is a schematic diagram of the RTD/Resistance Scanner.

TABLE 163-2. RTD/RESISTANCE SCANNER PCA
(SEE FIGURE 16:14:3.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 1- 3, 7,		CAP,POLYES,0.22UF,+-10%,50V	696492	89536	696492	7		
C 8, 11, 12			696492					
C 4, 14		CAP,POLYPR,0.047UF,+-10%,100V	446773	89536	446773	2		
C 5, 16		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE111Z5U224M50V	2		
C 6		CAP,CER,0.001UF,+-20%,100V,X7R	402966	72982	8121-A100-W5R-102M	1	1	
C 9, 13		CAP,TA,10UF,+-20%,15V	193623	56289	196D106X0015A1	2		
C 10, 17		CAP,CER,100PF,+-2%,100V,COG	512848	51406	RPE121	2		
C 15		CAP,POLYPR,470PF,+-5%,50V	740464	89536	740464	1		
CR 1- 4, 8-	•	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	24	1	
CR 27	•		203323					
H 1		SCREW,MACH,PHP,S STL,4-40X3/4	681973	89536	681973	1		
H 2		NUT,HEX,S.STL,4-40	147611	89536	147611	1		
H 3		WASHER	147603	89536	147603	6		
H 4		WASHER	195354	89536	195354	6		
H 5		WASHER	146225	89536	146225	6		
J 38		CONN,POST,PWB,.025SQ,NON-INSUL,GOLD30	513841	00779	1-87022-7	22		
K 0- 19		RELAY COIL ASSY	777631	89536	777631	20		
K 20- 22		RELAY,REED,1 FORM A,5VDC	520247	71707	UF-40115	3		
L 1		INDUCTOR,0.15 UH,+/-10%,400MHZ,SHLDED	256297	24759	MR0.15	1	1	
MP 2		SPACER,REED	617415	89536	617415	1		
MP 3		SPACER,SWAGED,RND,BRASS,0.125IDX0.187	436675	89536	436675	5		
MP 4		SPACER,SWGD,RND,BRASS,0.150IDX0.125	335075	89536	335075	1		
MP 5		BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1		
MP 6		BOTTOM GUARD	579151	89536	579151	1		
MP 7		PCB RETAINER	579078	89536	579078	2		
MP 8		INSULATOR, BOTTOM	579102	89536	579102	1		
P 38		CONN,PWB,REC,BOARD MOUNT,1/16 THICK	267476	00779	85861-2	22		
Q 1- 18, 23-	•	TRANSISTOR,SI,N-JFET,TO-92	376475	15818	U2810J	22		
Q 26	•		376475					
Q 19- 22, 27	•	TRANSISTOR,SI,P-MOS,ENHANCEMENT,TO-72	741058	89536	741058	5	5	
R 1, 2, 17,		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	5		
R 21, 25			348920					
R 3		RES,CC,330,+-5%,0.25W	147767	01121	CB3315	1		
R 4, 15, 30-		RES,MF,4.99K,+-1%,0.125W,100PPM	168252	91637	MFF1-04991	16		
R 36, 38, 39,			168252					
R 41- 45			168252					
R 5		RES,CC,100,+-5%,0.25W	147926	01121	CB1015	1		
R 6, 7		RES,MF,10K,+-0.1%,0.125W,25PPM	435065	89536	435065	2		
R 8, 10		RES,MF,4.75K,+-1%,0.125W,100PPM	260679	91637	CMF554751F	2		
R 9		RES,CC,910,+-5%,0.5W	170704	89536	170704	1		
R 11- 13		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	3		
R 14		RESISTOR,WW 200(	653287	89536	653287	1		
R 16		W W RESISTOR	730903	89536	730903	1		
R 18		W W RESISTOR 49.6K	743625	89536	743625	1	1	
R 19		W W RESISTOR 156K	743617	89536	743617	1	1	
R 20		RES,CF,20K,+-5%,0.25W	441477	80031	CR251-4-5P20K	1	1	
R 24		RES,5.0K(+-.05% 0+-5PPM TC 1/4W BOBB	288647	89536	288647	1	1	
R 37, 40		RES,CC,510,+-5%,0.25W	218032	01121	CB5115	2		
S 10- 79		SWITCH,REED,1 FORM A,10VA,36AT	647578	89536	647578	80		
U 1, 9, 17	•	IC,CMOS,QUAD 2 INPUT NAND GATE	453241	02735	CD4011BE	3	1	
U 2	•	IC,CMOS,QUAD 2 INPUT OR GATE	408393	02735	CD4071BE	1	1	
U 3, 6	•	IC,CMOS,BCD-DEC & BINRY-OCTAL DECODER	650689	89536	650689	2	1	
U 4, 7, 10	•	IC,ARRAY,7 TRANS,NPN,COMMON EMITTER	407846	49671	CA3081	3	1	
U 5, 8	•	IC,CMOS,DUAL 2 IN NAND DRVR W/OPN DRN	604207	02735	CD40107BE	2	1	
U 11, 12, 20,	•	IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980	06665	OP-07DP	4	1	
U 23	•		605980					
U 13, 15, 19	•	IC,COMPARATOR,QUAD,CERAMIC,14 PIN DIP	605584	89536	605584	3	1	
U 14	•	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	1	1	
U 16, 22	•	IC,OP AMP,GENERAL PURPOSE,TO-78 CASE	418368	89536	418368	2	1	
U 18	•	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001AE	1	1	
U 21	•	IC,OP AMP,JFET INPUT,8 PIN DIP	605568	89536	605568	1	1	
VR 1, 2	•	ZENER,UNCOMP, 18.0V, 5%, 7.0MA, 0.4W	327973	04713	1N967B	2	1	
VR 3	•	ZENER,UNCOMP, 5.1V, 5%, 20.0MA, 0.4W	159778	04713	1N751A	1	1	
VR 4	•	ZENER,UNCOMP, 4.7V, 5%, 20.0MA, 0.4W	524058	14552	1N751	1		
VR 5	•	ZENER REFERENCE SET	644539	89536	644539	1	5	

TABLE 163-2. RTD/RESISTANCE SCANNER PCA
(SEE FIGURE 163-14.)

REFERENCE DESIGNATOR A->NUMERICS---)	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
VR 22, 23	*		644539					
U 1, 2		CONN,PWB,HEADER,SIP,0.100,4 PIN	417329	89536	417329	2		
U 3, 4		CONN,PWB,HEADER,SIP,0.100,2 PIN	643916	28213	3469/20	2		
U 5, 6		JUMPER, RECEPTACLE	530253	00079	530153-2	2		
Z 1		RES,NET,SIP,8 PIN,7 RES,100K,+-2%	412908	89536	412908	1		
Z 2, 3		RES,NET,SIP,6 PIN,5 RES,100K,+-2%	412726	89536	412726	2		
Z 4	*	REF DIVIDER RNET ASSY TESTED 2280A	731018	89536	731018	1		

DESCRIPTION

The -164 Transducer Excitation Module (shown in Figure 164-1) provides excitation conditioning for the measurement of RTDs, low resistances, strain gauges, and strain gauge based transducers. Five precision current sources and one precision voltage source are available.

The -161 A/D Converter, -162 Thermocouple/DC Voltage Scanner, and -176 Voltage Input Connector are used to measure the transducer's response to the applied excitation. The excitation currents or voltages are connected to the transducer's excitation field wiring on the -174 Transducer Excitation Connector. Terminals are also provided on this connector to terminate the transducer sense wiring and to connect these signals to the Voltage Input Connector.

Excitation is provided for up to 20 measurements. The choice of voltage or current excitation is made in groups of five channels using a jumper on the Excitation Connector.
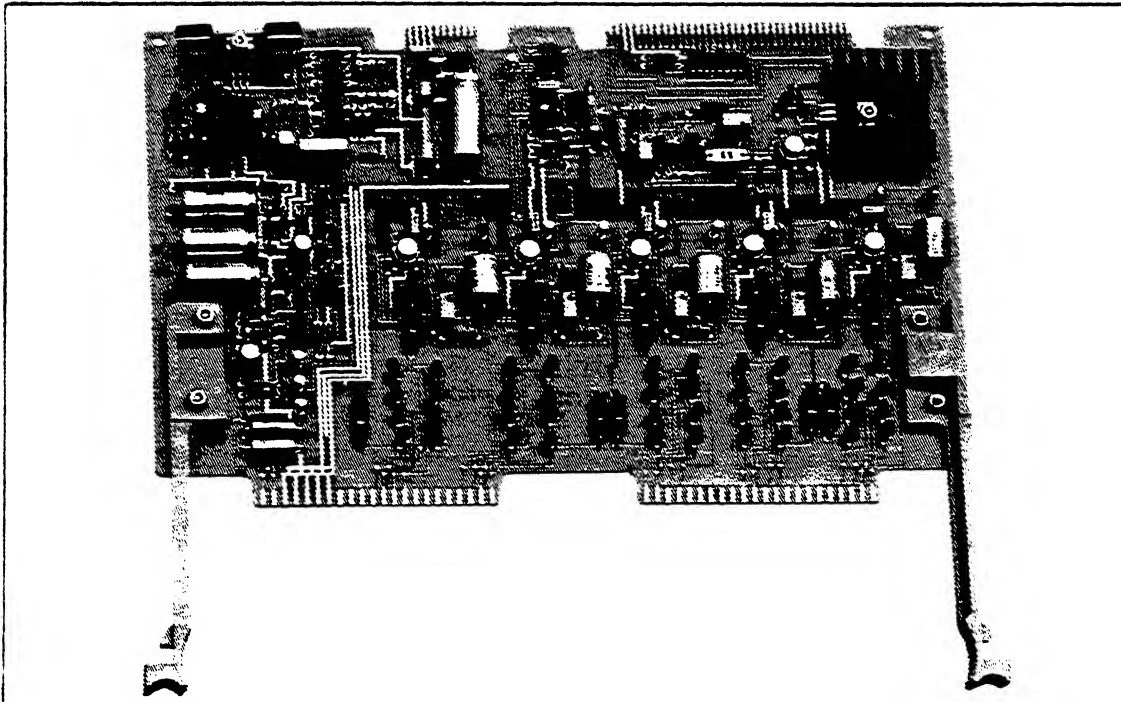
Figure 164-1. Transducer Excitation

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: -164 Transducer Excitation Module theory of operation, performance tests, calibration procedure, a parts list, and a schematic diagram.

Installation, operating and system configuration instructions are located in the System Manual. Option specifications can be found in the appendices to this manual and the System Manual.

The test equipment required to procedures in this subsection's is listed in Table 164-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

Table 164-1. Required Test Equipment for -164

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
Digital Multi-meter (DMM)	NA	Fluke 8505A
Resistance Calibrator	NA	Fluke 5450A
High Performance A/D Converter	NA	Fluke Option -161 (no substitute)
Thermocouple/DC Volts Scanner	NA	Fluke Option -162 (no substitute)
Voltage or Iso-Thermal Input Connector	NA	Fluke Option -175 or -176 (no substitute)
Transducer Excitation Connector	NA	Fluke Option -174 (no substitute)
Calibration/ Extender Fixture	NA	Fluke Accessory Y2056 Fluke Part No. 648741 (no substitute)
Resistor	499 ohms +/- 1% MF	Fluke Part No. 289256

THEORY OF OPERATION

The -164 Transducer Excitation Module theory of operation includes a functional description of the module and a detailed circuit description of each major circuit block. The schematic diagrams for the Transducer Excitation Module are located at the end of this option subsection.

Overall Functional Description

The Transducer Excitation Module obtains 24V dc power from the serial link and generates stable current and voltage outputs which are made available through the -174 Transducer Excitation Connector. Voltage or current excitation is provided for 20 channels, divided into five groups of four channels. One jumper, located on the Transducer Excitation Connector for each group of channels determines whether the four channels are to have voltage or current excitation.

Detailed Circuit Description

POWER SUPPLY

A switching power supply generates the voltages required and provides isolation for the voltage and current output sections of the Transducer Excitation Module. The power supply is a flyback type composed of T1, U1, one half of U2, U3, and U4. Incoming voltage is applied across the primary winding of T1 for an interval determined by U1, causing the primary current to ramp up to a peak of 1A (when the duty cycle is at a maximum of 50%). Q1 and Q2 are then turned off and the energy stored in T1 is released through CR6, CR7, CR8, and CR10 into C5, C9, C10, and C11. The cycle is repeated at a 32-kHz rate.

The 5.4V nominal voltage on C9 is compared, using U2, with a 2.5V reference voltage from U4. The resulting error signal is relayed to U1 through isolator U3. U1 uses this error information to control the amount of time that Q1 and Q2 are on, thereby maintaining 5.4V across C9 regardless of load or line changes.

The 10V supply is regulated by the linear regulator composed of one half of U2, Q4, and Q3. The 2.5V reference from U4 is compared to the divided-down 10V output by U2, which then uses Q4 to modulate the base current of Q3 and control the output voltage.

VOLTAGE OUTPUT

The voltage output is derived from a precision voltage reference and is driven by a unity-gain buffer amplifier. One of two output values, 2V or 4V, is selected by switch S1 by connecting one of these reference voltages to the input of the buffer amplifier. The buffer amplifier is a high-current, low-output-impedance driver suitable to drive various strain gauge and other transducers.
The buffer amplifier is composed of U5, Q5, and Q6. Transistor Q5 is an n-channel MOSFET used as the series pass element. Transistor Q6 senses

the current output and decreases the gate voltage to Q5 if the current exceeds 350 mA, thereby reducing the voltage output to limit the current. The buffer amplifier output voltage is divided in half by a pair of precision wire-wound resistors (R35 and R36). This voltage is made available on the connector for use in bridge completion.

CURRENT SOURCES

Five current sources (set at the factory to output 1 mA) are provided by the Transducer Excitation Module. Each current source is designed so that it can provide current for four series-connected RTDs, giving a total of 20 excitation points. If desired, the excitation current can be reduced by placing a resistor in series with the standard current-sense resistors, replacing JR1 (typical).

To provide fail-safe operation, a pair of diode-connected transistors are connected across each RTD or resistance being excited. If a point in the series string of four opens or is left open, the diodes conduct to ensure that the current continues to flow through the other points in the string.

Each current source is composed of an amplifier (U6 typical), a precision voltage reference (VR2), a current-sense resistor (series parallel combination of R45, R50, R55, and R60 typical), and a p-channel JFET (Q8 typical). The reference is shared by all five current sources. For each source, the amplifier maintains a constant voltage across a current sense resistor by controlling the on resistance of a p-channel JFET. Each current source is protected against transient voltage damage by two series resistors (R65 and R70 typical), which limit current flow, and two JFETs connected as diodes (Q13 and Q18 typical) which clamp any transient voltages.

COMMUNICATION

The Transducer Excitation Module can be installed in any serial link slot in the Front End. In practice, however, the module is usually installed below the scanner used to measure the transducer response to the excitation. When the A/D Converter selects the slot by setting BLCT SCT2 high, the Transducer Excitation Module answers with its type code of 5. Integrated circuit U12 detects the request and responds by turning on its outputs.

GENERAL MAINTENANCE

The Transducer Excitation Module normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the instruction provided in Section 4 of this manual.

PERFORMANCE TEST

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES
THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED
PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT.
TURN OFF THE COMPUTER FRONT END AND REMOVE ALL
POWER SOURCES BEFORE PERFORMING THE FOLLOWING
PROCEDURE.

The following performance tests will verify that the Transducer
Excitation Module and Transducer Excitation Connector are operating
properly within specified tolerance.

The following two tests are required to verify the proper operation of
the assembly:

o   Current Excitation Test

o   Voltage Excitation Test

The procedures for conducting these tests follow.

Current Excitation Performance Test

To test current excitation, perform the following procedure:

1.   Switch OFF power to the Front End. Disconnect the ac line cord and
      all other high voltage inputs.

2.   Install a -161 High Performance A/D Converter in the uppermost
      option slot of the Front End. The address switch on the A/D must be
      set to 0.

3.   Install a -162 Thermocouple/DC Volts Scanner in the slot directly
      below the A/D Converter. The channels will be measured as channels
      0 through 19.

4.   Install the Transducer Excitation Module to be tested in the slot
      directly below the Thermocuple/DC Volts Scanner. The voltage
      excitation switch, S1, must be in the 4V position.

5.   Install the five jumpers on a Transducer Excitation Connector in
      the current excitation position.

6.   Wire the Transducer Excitation Connector to an Isothermal Input or
      Voltage Input Connector according to the diagram in Figure 164-2.

7.   Install the Transducer Excitation Connector on the Transducer
      Excitation Module, and install the Isothermal or Voltage Input
      Connector on the Thermocouple/DC Volts Scanner.

8.   Reconnect the ac line cord to the Front End, and switch power ON.

VOLTAGE INPUT CONNECTOR or ISOTHERMAL INPUT CONNECTOR			TRANSDUCER EXCITATION CONNECTOR		
Channel 0	HI Terminal	O------------O	Channel 1	A Terminal
0	LO	O---+--------O	2	D
0	SH	O---+		
Channel 4	HI Terminal	O------------O	Channel 5	A Terminal
4	LO	O---+--------O	6	D
4	SH	O---+		
Channel 8	HI Terminal	O------------O	Channel 9	A Terminal
8	LO	O---+--------O	10	D
8	SH	O---+		
Channel 12	HI Terminal	O------------O	Channel 13	A Terminal
12	LO	O---+--------O	14	D
12	SH	O---+		
Channel 16	HI Terminal	O------------O	Channel 17	A Terminal
16	LO	O---+--------O	18	D
16	SH	O---+		
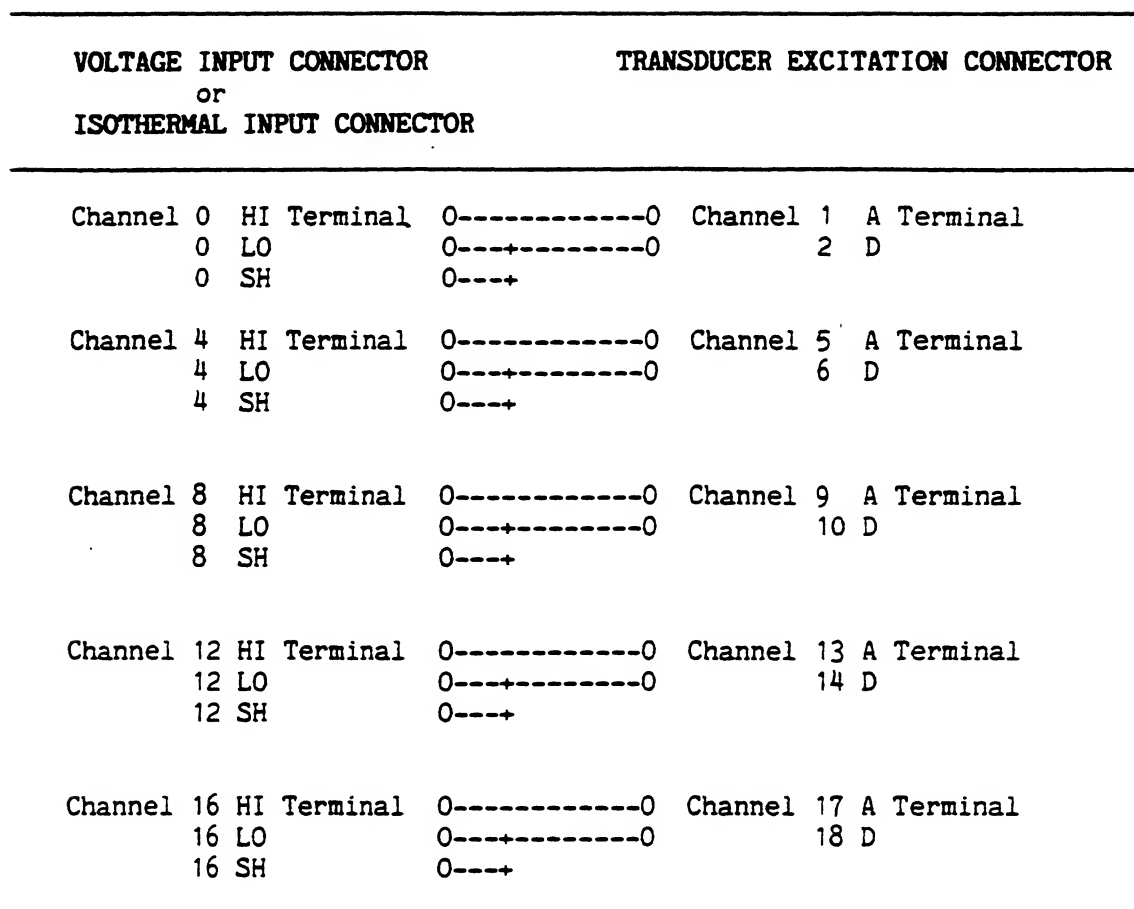
Figure 164-2. Current Excitation Test Wiring Diagram 1

9. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..19)=DVIN,MAX=7.9 <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0,4,8,12,16) <CR>
```

The measurement returned on each channel (0, 4, 8, 12,and 16) should be between 5.2V and 5.6V.

If the measurement is outside this range, one of the shunt diodes located on the Transducer Excitation Module may be shorted or open.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
100   GOSUB 300
120   PRINT #1,"def chan(0..19)=dvin,max=7.9"
125   GOSUB 300
130   PRINT #1,"format=decimal"
140   GOSUB 300
150   REM make measurement and read in response
160   PRINT #1,"send chan(0,4,8,12,16)"
170   FOR I=0 TO 16 STEP 4
180   INPUT #1,M$
190   PRINT "chan";I;"=";
200   PRINT USING "##.#####";VAL(M$);
210   PRINT " Volts DC"
220   NEXT I
230   END
300   REM wait for message accepted prompt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1%
50    OPEN "KB1:"AS OLD FILE 2%
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"count=off"
110   GOSUB 300
120   PRINT #1,"def chan(0..19)=dvin,max=7.9"
130   GOSUB 300
140   PRINT #1,"format=decimal"
150   GOSUB 300
160   REM make measurement and read in response
170   PRINT #1,"send chan(0,4,8,12,16)"
180   FOR I=0 TO 16 STEP 4
190   INPUT #2,M$
200   PRINT "chan";I;"=";
210   PRINT USING "S##.#####",VAL(M$);
220   PRINT " Volts DC"
230   NEXT I
240   END
300   REM wait for message accepted prompt
310   INPUT #2,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

The measurement returned on each channel (0, 4, 8, 12,and 16) should be between 5.2 and 5.6 volts.

If the measurement is outside this range, one of the shunt diodes located on the Transducer Excitation Module may be either shorted or open.

10. Switch OFF power to the Front End and remove the previously wired connectors.

Rewire for channels 0, 4, 8, 12 and 16 as shown for channel 0 in Figure 164-3.

NOTE

A 499-ohm +/- 1% resistor must be installed between terminals A and D on channels 0, 4, 8, 12, and 16 of the connector.

11. Install the rewired Transducer Excitation Connector on the Transducer Excitation Module, and install the rewired Voltage or Isothermal Input Connector on the Thermocouple/DC Volts Scanner.

)

VOLTAGE INPUT CONNECTOR or ISOTHERMAL INPUT CONNECTOR		TRANSDUCER EXCITATION CONNECTOR	
Channel #	Terminal	Channel #	Terminal
0	HI ---------------------- 0		A ---|
			\ 499 ohm
			/ resistor
0	LO ---------------------- 0		D ---|
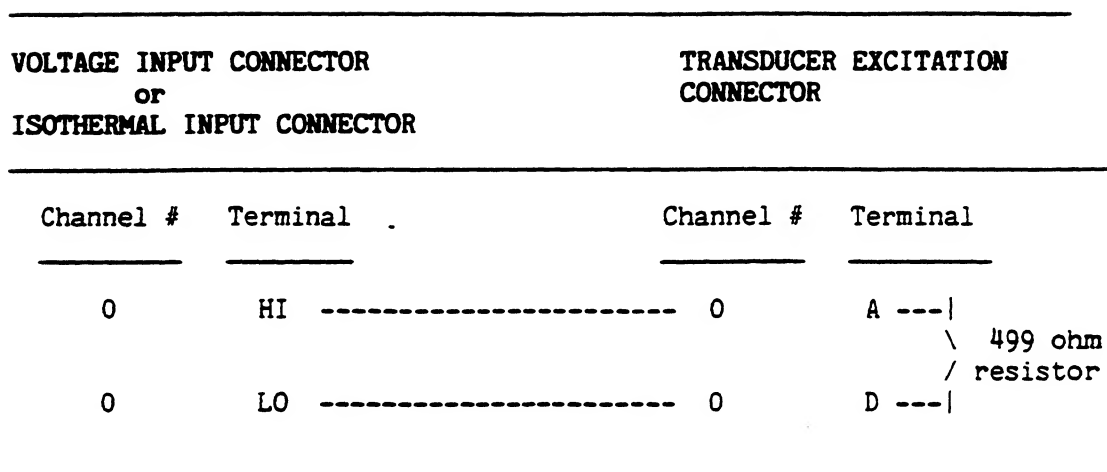
Figure 164-3. Current Excitation Test Wiring Diagram 2

12. Switch power to the Front End ON.

13. Redefine channels 0 through 19 to measure a dc voltage on the 512 mV range.

   To redefine the channels in the Terminal Mode, send the following command:

   DEF CHAN(0..19)=DVIN, MAX=0.5 <CR>

   To redefine the channels in the Computer Mode, change the BASIC statement in line 120 to:

   PRINT #1,"def chan(0..19)=dvin, max=0.5"

14. Request a measurement on channels 0, 4, 8, 12, and 16.

   The returned readings should be 499 mV, +/- 5.1 mV. This is the voltage drop across the 499-ohm resistor due to the 1 mA excitation. If a more accurate measurement of this current is desired, a digital multimeter (DMM) can be used to measure it directly.

15. This completes the Current Excitation Test.

Voltage Excitation Performance Test

To test voltage excitation, perform the following procedure:

1. Perform the Current Excitation Performance Test if you have not already done so.

2. Switch OFF power to the Front End and remove both the connectors.

3.   Move the five jumpers on the Transducer Excitation Connector to the voltage excitation position.

Rewire as shown in the Figure 164-4. Connect as shown for channel 0, 4, 8, 12, and 16.

VOLTAGE INPUT CONNECTOR or ISOTHERMAL INPUT CONNECTOR		TRANSDUCER INPUT CONNECTOR	
Channel #	Terminal	Channel #	Terminal
0	HI --------------------- 0		A
0	LO --------------------- 0		D
4	HI --------------------- 4		A
4	LO --------------------- 4		D

Figure 164-4. Voltage Excitation Test Wiring Diagram

4.   Install the rewired Transducer Excitation Connector on the Transducer Excitation Module and install the rewired Voltage or Isothermal Input Connector to the Thermocouple/DC Volts Scanner.

5.   Switch ON power to the Front End.

6.   Program the Front End to measure channels 0, 4, 8, 12, and 16 on the 8V range by performing step 9 of the Current Excitation Test.

The measured value for each channel should be 4.0V +/- 0.004V.

7.   This completes the Voltage Excitation Performance Test.

CALIBRATION

Perform the following procedures to calibrate the precision voltage and current sources on the Transducer Excitation Module.

Voltage Excitation Calibration

1.   Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2.   Install a Calibration/Extender Fixture (Part No. 648741) in any option position. Set the fixture switch to the EXTEND position.

3.   Install the Transducer Excitation Module on the Fixture. Put slide switch S1 into the 4V position.

4. Reconnect the ac line cord to the Front End and turn the power ON.

5. After the Transducer Excitation Module has warmed up for at least 30 minutes, connect the positive lead of the DMM to test point TP100 and connect the negative lead to test point TP4.

6. Set the DMM to measure 4V with a resolution of 0.00001V (10 uV).

7. Adjust R23 for a DMM reading of 4.00000V within a tolerance of 0.00001V (10 uV).

8. Put slide switch S1 in the 2V position. Set the DMM to measure 2V with a resolution of 0.000001V (1 uV).

9. Adjust R31 for a DMM reading of 2.000000V within a tolerance of 0.000001V (1 uV).

10. Put slide switch S1 in the proper position for your application.

This completes the voltage excitation calibration.

Current Excitation Calibration

<center>NOTE</center>

> If a precision resistor of known value is not available, the 8505A may be used with a stable resistor of 250 ohms. Using the DMM in 4-wire mode, measure the resistor on the 100-ohm range (sic). Use the resulting value when performing the calibration procedure provided below.

1. Perform the setup steps 1 through 4 from the voltage excitation calibration procedure given previously.

2. Again, make sure the Transducer Excitation Module has warmed up for at least 30 minutes, then connect the DMM high lead to test point TP21 and connect the low lead to test point TP101.

3. Set the DMM to measure on the 10V range with a resolution of 0.0001V (100 uV).

4. Adjust R42 for 6.2000V within a tolerance of 0.0002V (200 uV).

5. Power down the Front End and install a -174 Transducer Excitation Connector assembly on the Transducer Excitation Module.

6. Put the programming jumpers on the Transducer Excitation Connector in the current output position.

7. Connect the DMM, the Resistance Calibrator, and the Transducer Excitation as follows, where Terminal A and D on the Transducer Excitation Connector are those of channel 0.

```
8505A              5450A                              Option -174

                   SENSE      OUTPUT
       HI          HI         HI
       O---------------O      O----------------O Terminal A

       LO          LO         LO
       O---------------O      O----------------O Terminal D
```

8. Set the Resistance Calibrator to 190 ohms nominal.

9. Set the DMM to measure on the 1V range with 1 uV resolution, with the average mode enabled. The DMM must have been calibrated within 90 days and also have been software calibrated within the last 24 hours.

10. To calibrate the current source for channels 0, 1, 2, and 3, adjust R55, so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

11. Repeat the current calibration procedure for the current source for channels 4, 5, 6, and 7 by moving the Terminal A and D connections from channel 0 to channel 4 and adjusting R56 so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

12. Repeat the current calibration procedure for the current source for channels 8, 9, 10, and 11 by moving the Terminal A and D connections from channel 4 to channel 8 and adjusting R57 so that .the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

13. Repeat the current calibration procedure for the current source for channels 12, 13, 14, and 15 by moving the Terminal A and D connections from channel 8 to channel 12 and adjusting R58 so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

14. Repeat the current calibration procedure for the current source for channels 16, 17, 18, and 19 by moving the Terminal A and D connections from channel 12 to channel 16 and adjusting R59 so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

15. The calibration of the Transducer Excitation Module is complete.

16. Switch power to the Front End OFF.

17. Remove the Transducer Excitation Module from the Calibration/Extender Fixture.

18. Remove the Fixture from the Front End.

19. Install the Transducer Excitation Module in the Front End (or Extension Chassis) for normal operation.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Transducer Excitation Module is given in Table 164-2.

For parts ordering information, see Section 6 of this manual.

Figure 164-5 is a schematic diagram of the Transducer Excitation Module.

TABLE 164-2. -164 TRANSDUCER EXCITATION PCA
(SEE FIGURE 164-5.)

REFERENCE DESIGNATOR A->NUMERICS---> S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 1, 20- 25	CAP,POLYES,0.1UF,+-10Z,50V	696484	89536	696484	7		
C 2	CAP,AL,330UF,+100-10Z,35V	614404	89536	614404	1		
C 3	CAP,CER,1000PF,+-5Z,50V,C0G	528539	51406	RPE113	1		
C 4	CAP,POLYES,0.022UF,+-10Z,50V	715268	89534	715268	1		
C 5, 12, 13	CAP,AL,47UF,+-20Z,16V	643304	89536	643304	3		
C 6	CAP,CER,1000PF,+-10Z,500V,X5S	357806	56289	C0163102G102K	1		
C 7	CAP,POLYES,1.0UF,+-10Z,50V	733089	89536	733089	1		
C 8	CAP,CER,0.0012UF,+-10Z,500V,Z5R	106732	71590	CF122	1		
C 9	CAP,AL,470UF,+100-10Z,12V	602649	89536	602649	1		
C 10, 11	CAP,AL,270UF,+100-10Z,20V	602656	89536	602656	2		
C 14- 19	CAP,CER,33PF,+-2Z,100V,C0G	513226	51406	RPE121	6		
CR 3, 5, 6,	● DIODE,SI,BV= 75.0V,I0=150MA,500 MW	203323	07910	1N4448	4		
CR 11	●	203323					
CR 7	● DIODE,SI, 20 PIV, 1.0 AMP	507731	83003	VSK120	1	1	
CR 8, 10	● DIODE,SI, 50 PIV, 1.0 AMP	379412	04713	1N4933	2	1	
E 13- 17	TERM,INSUL,FEEDTHRU,MULTILEAD,BLUE	529297	98291	011-6812-00-0-206	5		
F 1	FUSE,1/4 X 1-1/4,FAST,0.5A,250V	153858	71400	AGC1-2	1		
H 1	WASHER,LOCK,SPLIT,STEEL,#4	110395	89536	110395	4		
H 1	INSERT,STUD,BROACHING,PHOSPHOR BRONZE	494682	89536	494682	2	1	
H 2	NUT,MACH,HEX,STL,4-40	110635	89536	110635	4		
H 2	INSERT,STUD,BROACHING,PHOSPHOR BRONZE	614636	89536	614636	2		
H 3	WASHER,FLAT,BRASS,#4,0.025	110775	89536	110775	4		
H 4	SCREW,MACH,PNP,STL,6-32X3/8	152165	89536	152165	2		
H 5	WASHER,FLAT,BRASS,#6,0.012 THK	111054	89536	111054	2		
H 6	WASHER,LOCK,SPLIT,STEEL,#6	110692	89536	110692	2		
H 7	NUT,HEX,MINI,S.STL,6-32	110569	89536	110569	2		
JR 1- 5	TERM,UNINSUL,STANDOFF,TURRET,SWAGE	100586	89536	100586	15	1	
L 1, 2	CHOKE,6TURN	320911	89536	320911	2		
MP 1	RETAINER,P.C.B.	579078	89536	579078	2		
MP 2	HEAT SINK, XISTOR THERMALLOY 6072B	473686	89536	473686	1		
MP 3	HLDR,FUSE,1/4,PWB MT	485219	91833	3529	2		
MP 4	SPACER,RND,ALUM,0.156IDX0.250	153155	89536	153155	2	5	
MP 5	BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1		
MP 6	HEATSINK, INNER, U1	473660	13103	6070B	1	1	
Q 1	● TRANSISTOR,SI,NPN,HI-VOLTAGE	370684	04713	MPS A 42	1	1	
Q 2	● SILICON, NPN, FAST SWITCHING D44H11	535542	89536	535542	1		
Q 3, 7	● TRANSISTOR,SI,PNP,SMALL SIGNAL	340026	04713	MPS6563	2	1	
Q 4, 23- 62	● TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	41	1	
Q 5	● TRANSISTOR,SI,NMOS,75W,TO-220	586107	89536	586107	1	1	
Q 6	● TRANSISTOR,SI,NPN,SELECTD,TEMP SENSOR	640862	89536	640862	1	9	
Q 8- 17	● TRANSISTOR,SI,P-JFET,TO-92	413690	89536	413690	10	1	
Q 18- 22	● TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	429977	89536	429977	5	2	
R 1, 2, 4	RES,MF,4.99K,+-1Z,0.125W,100PPM	168252	91637	MFF1-84991	3		
R 3	RES,MF,4.75K,+-1Z,0.125W,100PPM	260679	91637	CMF554751F	1		
R 5	RES,MF,15.8K,+-1Z,0.125W,100PPM	293688	91637	CMF551582F	1		
R 6	RES,MF,39.2K,+-1Z,0.125W,100PPM	236414	91637	CMF553922F	1		
R 8	RES,CF,1.8K,+-5Z,0.25W	441444	80031	CR251-4-5P1K8	1		
R 9, 18	RES,CF,510,+-5Z,0.25W	441600	80031	CR251-4-5P510E	2		
R 10	RES,CF,1.5K,+-5Z,0.25W	343418	80031	CR251-4-5P1K5	1		
R 11, 16	RES,CF,330,+-5Z,0.25W	368720	80031	CR251-4-5P330E	2		
R 12	RES,CF,100,+-5Z,0.25W	348771	80031	CR251-4-5P100E	1		
R 13, 14	RES,MF,100K,+-1Z,0.125W,100PPM	248807	91637	CMF551003F	2		
R 15	RES,MF,82.5K,+-1Z,0.125W,100PPM	246223	91637	CMF558252F	1		
R 17	RES,MF,10.7K,+-1Z,0.125W,25PPM	423681	91637	CMF551072F	1		
R 19	RES,MF,3.57K,+-1Z,0.125W,25PPM	376905	89536	376905	1		
R 20	RES,CF,51,+-5Z,0.25W	414540	80031	CR251-4-5P51E	1		
R 23, 31, 55- 59	RES,VAR,CERM,1K,+-10Z,0.5W	393728 393728	32997	3299W-CR2-102	7		
R 24	RES,MF,3.92K,+-1Z,0.125W,100PPM	294801	91637	CMF553921F	1		
R 25	RES,MF,7.5K,+-1Z,0.125W,25PPM	484881	89536	484881	1		

TABLE 164-2. -164 TRANSDUCER EXCITATION PCA
(SEE FIGURE 164-5.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
R	26		RES,WW,23.7K,+-0.1%,0.15W	385609	89536	385609	1		
R	27, 29		RES,WW,20K,+-0.1%,0.125W	271395	89536	271395	2	1	
R	28		RES,MF,53.6,+-1%,0.125W,100PPM	339861	91637	CMF5553R6F	1	1	
R	30		RES,MF,287K,+-1%,0.125W,25PPM	257543	89536	257543	1		
R	32, 37, 43,		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	5		
R	44, 77			348839					
R	33		RES,CF,13K,+-5%,0.25W	441402	80031	CR251-4-5P13K	1		
R	34		RES,CF,1.5,+-5%,0.25W	442020	89536	442020	1		
R	35, 36		W W RESISTOR	719377	89536	719377	2		
R	40		RES,WW,60.75K,+-0.1%,0.15W	385625	89536	385625	1	1	
R	41		RES,MF,750,+-1%,0.125W,25PPM	448035	89536	448035	1	1	
R	42		RES,VAR,CERM,500,+-10%,0.5W	325613	89536	325613	1		
R	45- 49		W W RESISTOR	719344	89536	719344	5		
R	50- 54		RES,CF,5.6M,+-5%,0.25W	543371	80031	CR251-4-5P5M6	5	1	
R	60- 64		RES,MF,10.5,+-1%,0.125W,100PPM	494492	89536	494492	5		
R	65- 74		RES,WW,FUSIBLE,1K,+-10%,2W	474080	89536	474080	10		
R	75		RES,CF,160,+-5%,0.25W	441410	80031	CR251-4-5P160E	1		
R	76		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	1		
R	78		RES,CF,220,+-5%,0.25W	342626	80031	CR251-4-5P220E	1		
S	1		SWITCH,SLIDE,SPDT	453365	34828	G1-116-0001-G20-52	1		
T	1		INVERTER TRANSFORMER	580407	89536	580407	1		
U	1	•	IC,REGULATING PULSE WIDTH MODULATOR	454678	01295	SG3524N	1	1	
U	2	•	IC,OP AMP,DUAL,INDUSTRIAL TEMP RANGE	605550	01295	LM258JG	1	1	
U	3	•	ISOLATOR,OPTO,HI-SPEED,8 PIN DIP	354746	89536	354746	1	1	
U	4	•	IC, 2.5 V,40 PPM T.C.,BANDGAP REF	472845	04713	MC1403V	1	1	
U	5- 10	•	IC,OP AMP,GENERAL PURPOSE,TO-78 CASE	418368	89536	418368	6	1	
U	11	•	IC,OP AMP,MOSFET INPUT,8 PIN DIP	507426	89536	507426	1	2	
U	12	•	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	1	1	
VR	1, 2	•	ZENER REFERENCE SET	646539	89536	646539	2		
VR	21, 22, 38,	•		646539					
VR	39	•		646539					
VR	3	•	ZENER,UNCOMP, 10.0V, 5%, 25.0MA, 1.0W	340695	12969	UZ8710	1	1	
VR	5	•	ZENER,UNCOMP, 3.3V,10%, 20.0MA, 0.4W	309799	04713	1N746	1	1	

NOTE 1 = ALSO INCLUDES TP4,14,21,100,101.

579441   579441
580969   580969

DESCRIPTION

The -167 Counter/Totalizer (shown in Figure 167-1) is a six-channel option that supports event counting and frequency measurement.

Switches on the Counter/Totalizer assembly determine the function of each channel. The channels are grouped in pairs. There are three pairs of channels: channels 0 and 1, channels 2 and 3, and channels 4 and 5. Both channels in a pair must have the same function.

The Counter/Totalizer has adjustments that allow it to measure a variety of signal types. The reference voltage and input deadband are adjustable. These adjustments define the high and low voltage thresholds of the input. Debouncers and input pull-ups allow the Counter/Totalizer to count contact closures.

Physically, the Counter/Totalizer consists of a single printed circuit board assembly, a rear panel, and a 22-pin screw terminal connector. The assembly slides into the back of the Front End or 2281A chassis and is secured by rear panel screws.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: the Counter/Totalizer theory of operation, performance tests, parts list, and schematic diagrams.

Installation, operating, and system configuration instructions are found in the Helios I System Manual. Option specifications are included in the appendices of this manual and in the System Manual.

The equipment required to perform the procedures in this subsection is listed in Table 167-1. A summary of test equipment required for all procedures in this manual is given in Table 2-2 in Section 2.

Table 167-1. Required Test Equipment for -167

INSTRUMENT	RECOMMENDED MODEL
Digital Multimeter (DMM)	Fluke 77 or equivalent
Calibration/ Extender Fixture (Optional)	Fluke Accessory Part No. 648741
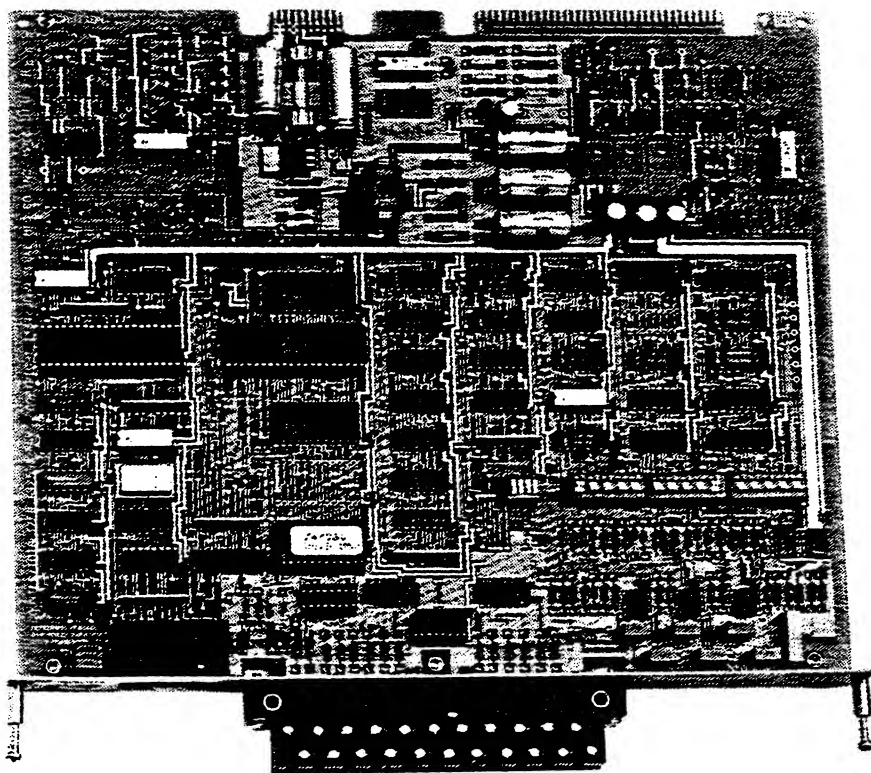
Figure 167-1. Counter/Totalizer

THEORY OF OPERATION

The -167 Counter/Totalizer monitors the signals on each of its six input channels. Depending on the function selected for each channel, the Counter/Totalizer either measures the frequency of the input signal or counts the number of high-to-low voltage transitions that occur. On command from the Front End controller, the Counter/Totalizer returns the measurements that it has obtained.

Measurement Techniques

To take totalizing and frequency measurements, each channel of the Counter/Totalizer uses a 23-bit binary counter. The counters are used differently, depending on the type of measurement to be made.

EVENT COUNTING

On an event-counting channel, each reading indicates the number of events that have occurred since the channel was last scanned. The event counter is reset to zero at the start of scanning. After each scan reading, the counter is reset again.

To ensure that no counts are lost during scanning, the counter must run continuously. The reset is performed in software by the Counter/Totalizer. Each time an event-counting channel is scanned, the Counter/Totalizer reads the running counter and stores the value. When the next scan occurs, the Counter/Totalizer reads a new counter value and computes the measurement by taking the difference between the previously stored value and the new one. The new counter value is stored away so that the process can be repeated.

The maximum number of events that can be counted between scans is 8,388,607. If more events than this occur, the reading is declared overrange. Monitoring an event channel does not reset the counter. This ensures that the monitoring and scanning operations do not interfere with each other.

FREQUENCY

To measure frequency, the Counter/Totalizer uses two counters. One counter is driven by an internal reference clock; the other is driven by the input signal. To take the measurement, the Counter/Totalizer resets both counters, then starts both counters on an input trigger. After the sample time has elapsed, the Counter/Totalizer stops both counters on the next input trigger.

In this way, the Counter/Totalizer always samples a whole number of input cycles. The measurement resolution is independent of input frequency, depending instead on the reference clock frequency and the sample time. An underrange frequency is detected if no input trigger occurs during the sample time.

To minimize circuitry, the Counter/Totalizer shares counters between a pair of channels. The three channel pairs are channels 0 and 1, channels 2 and 3, and channels 4 and 5. When the Counter/Totalizer measures frequency on an even-numbered channel, the even-numbered counter counts external triggers, while the odd-numbered counter accumulates reference counts. When the Counter/Totalizer measures on an odd-numbered channel, the counter roles are reversed.

Block Diagram Description

The major circuit blocks of the Counter/Totalizer are shown in Figure 167-2.

POWER SUPPLY AND REFERENCE VOLTAGES

The power supply converts incoming dc power from the serial link into isolated +14V, -15V, and +5V dc for the measurement circuitry as well as +5VREM for the serial link circuitry. The power supply also generates a reset signal that starts the microcomputer at power-up.

The reference voltage circuitry supplies threshold levels for the input conditioners. There is a fixed reference voltage, which is selectable for 0V or 1.4V (TTL level). There is also a variable reference, that is adjustable from -10 to +10V.

SERIAL LINK INTERFACE

The serial link allows the Counter/Totalizer to receive commands from the Front End controller and to send responses back. The serial link interface connects the 8-bit microcomputer data bus to the 25,000 baud transmit and receive lines.

MICROCOMPUTER AND STATUS/CONTROL REGISTERS

The microcomputer communicates with the Front End controller through the serial link. Through the status and control registers, the microcomputer controls the measurements on all six channels and gathers the results.

CLOCK GENERATOR

The clock generator section produces clock signals used by the microcomputer, the serial link, the input conditioners, and the measurement control section.

COUNTERS AND MEASUREMENT CONTROL SECTION

The measurement control section routes the input signals and the frequency reference clock into the six counters under direction of the microcomputer. This section also controls the counter gates that start or stop the counters. Status signals from the measurement control section allow the microcomputer to check measurement progress. The microcomputer can load or read the counters as necessary.
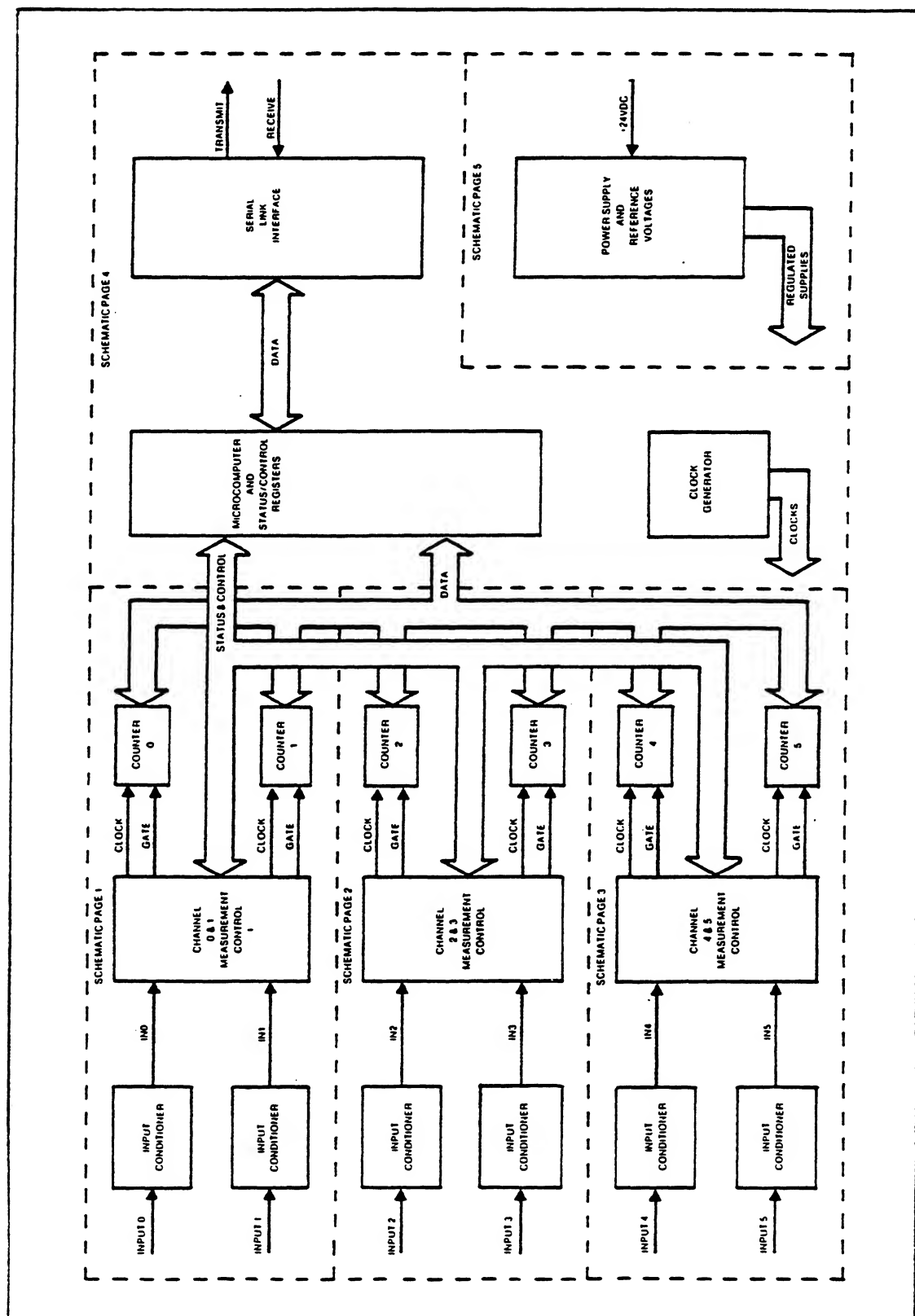
Figure 167-2. Counter/Totalizer Block Diagram

INPUT CONDITIONERS

The input conditioners convert the input waveforms into clean signals for triggering the counters. The input conditioners allow the Counter/Totalizer to sample waveforms of widely varying threshold levels.

Each input conditioner can use either the fixed or variable reference voltage. The input deadband for each channel can be adjusted from 0 to 3 volts. The reference voltage and deadband define the high and low input voltage thresholds. Each input conditioner includes a debouncer for accurate counting of contact closures.

Detailed Circuit Description

Many of the important signals on the Counter/Totalizer assembly are accessible at test point socket X1. These signals are described in the paragraphs that follow and are marked on the schematic diagram by solid black squares.

POWER SUPPLY AND REFERENCE VOLTAGES

DC to DC Converter

The power supply is a flyback converter that accepts 10 to 25V from the serial link. See Figure 167-3 for a simplified schematic.

Transformer T1 provides electrical isolation. When transistor Q4 is turned on, rectifier diodes CR12, CR13, and CR14 turn off, and the primary current in T1 ramps up. Turning Q4 off causes the energy stored in T1 to be released through the secondaries and the diodes. The voltage on C15 is sampled by level sensor U10, and an error signal is transmitted through the optocoupler back to the control circuitry.

The control circuitry of U6, U7, and U8 varies the duty cycle of Q4 (the percentage of time Q4 is on) to control the output voltage. If the voltage on C15 is too low, the control circuit increases the duty cycle. If the voltage is too high, the duty cycle is decreased. In this way, the secondary voltages are maintained despite variations in load current and serial link supply voltage. Proper operation of U6 can be verified by observing a 1 to 3.5V sawtooth with a period of about 18 microseconds on pin 7.

Linear regulators convert the secondary voltages to the +5V, +14V, and -15V levels needed by the measurement and control circuitry. The serial link drivers and receivers are powered by the +5VREM voltage from C1.

Power-On Reset

The power-on reset circuit withdraws the POR reset signal 50 ms after +5V power has been established. It asserts the reset signal immediately if the supply falls out of regulation.
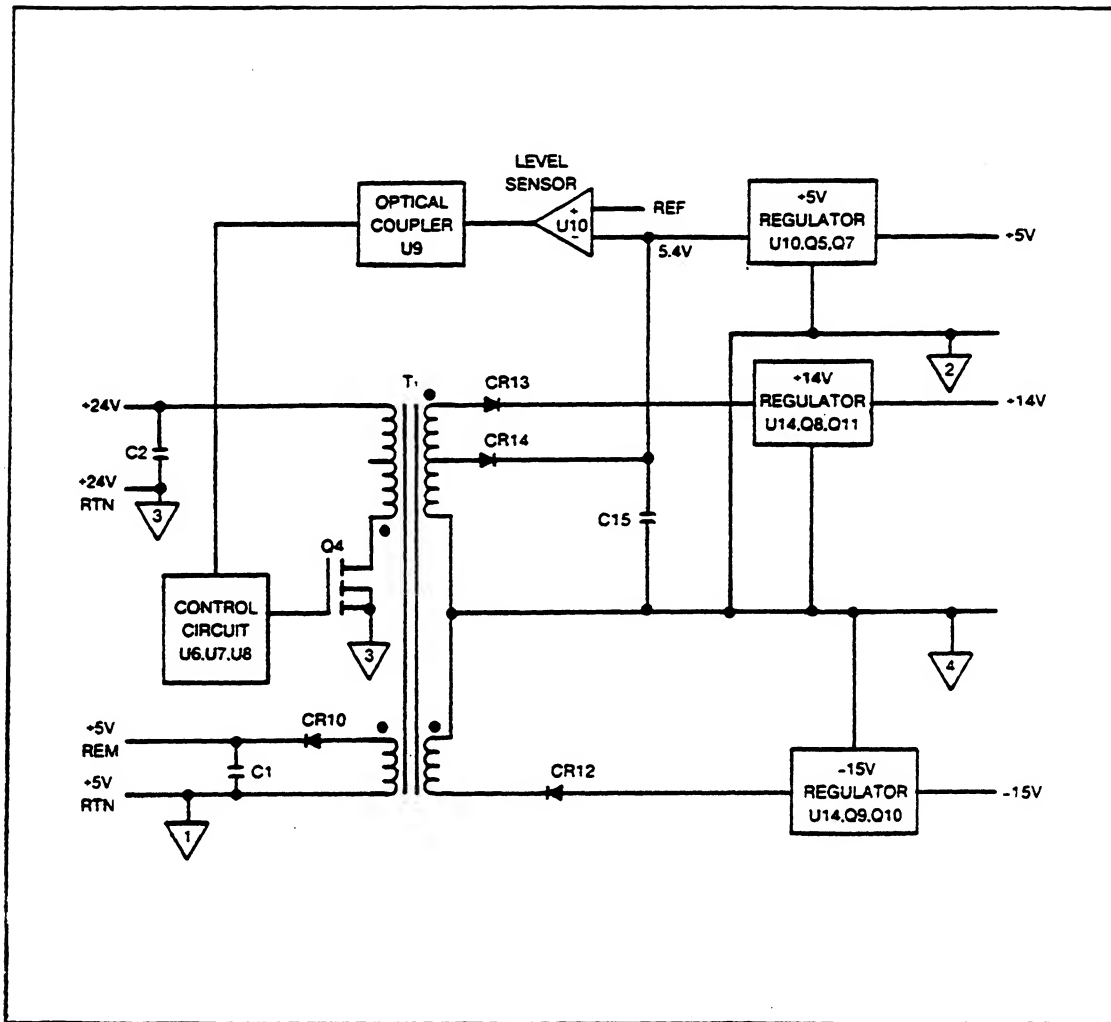
Figure 167-3. Power Supply Simplified Schematic

The circuit has two comparator stages. The first stage senses whether the +5V supply voltage is within tolerance. The second stage, because of capacitor C10, causes a time delay. When the supply voltage rises to a satisfactory level, the first stage allows C10 to charge slowly, eventually tripping the second comparator and withdrawing the reset signal. When the supply voltage falls, however, the first comparator discharges C10 quickly, causing the reset signal to be asserted without delay.

Reference Voltages

The input conditioner reference voltages are derived from the +14V and -15V power supplies through resistive voltage dividers. Voltage followers U58 and U65 buffer the reference voltages from variations in load current. Switch S2 connects the fixed reference line to either a 0-volt or 1.4-volt (TTL) level. Potentiometer R116 allows the variable reference voltage to be adjusted from -10 to +10V.

SERIAL LINK INTERFACE

Serial data is transferred between the Front End controller and the Counter/Totalizer via differential driver U2 and differential receiver U3.

A control line from the microcomputer places the serial link driver in a high-impedance state between data transmissions. Optical couplers U4 and U5 isolate the serial link driver and receiver electrically from the rest of the Counter/Totalizer circuitry.

Universal Asynchronous Receiver/Transmitter (UART) U29 converts data from the 8-bit parallel format of the microcomputer to the bit serial format of the serial link. The UART transmits and receives data at 25,000 baud. When the UART receives a character from the serial link, it drives the Data Ready (DR) line to a logical 1 to interrupt the micro-computer. When the microcomputer reads the character from the UART, the DR line returns to a logical 0.

The following paragraphs describe how the microcomputer reads data from and writes data to devices on the Counter/Totalizer assembly.

MICROCOMPUTER AND STATUS/CONTROL REGISTERS

The Counter/Totalizer microcomputer U28 executes a program stored in one or both of the read-only memories (EPROMs), U49 and U57.

Measurement results and control information are stored in the microcomputer's internal memory (RAM). Figure 167-4 shows a block diagram of this section of the Counter/Totalizer circuitry.

Before reading or writing data, the microcomputer drives a 12-bit address onto the data bus and the lower bits of port 2. The lower eight address bits are captured in latch U56 on the falling edge of the ALE signal. The port 2 address bits need not be latched. Decoder U53 uses four of the address bits to select one of the status or control registers on the assembly.

To read from the UART, counters, or status registers, the microcomputer drives the RD signal low. To write to the UART, counters, or control registers, the microcomputer drives the WR signal low.

To read from the EPROM, the microcomputer drives the PSEN signal low. Table 167-2 lists the registers that can be addressed by the microcomputer. The addresses are in hexadecimal. Non-specific (don't care) addresses are indicated by an X.
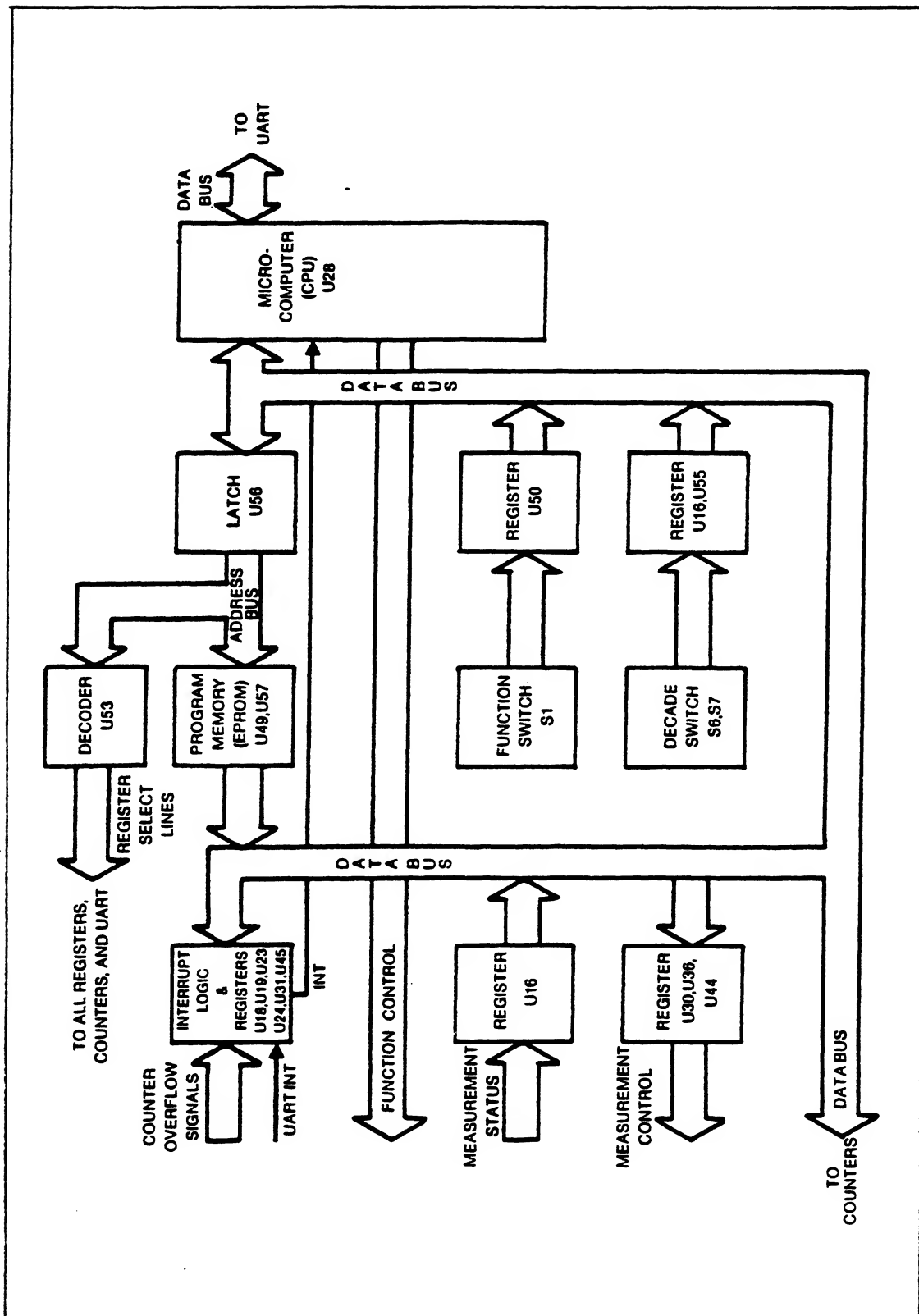
Figure 167-4. Microcomputer and Status/Control Registers Block Diagram

Table 167-2. Microcomputer U28 External Registers

ADDRESS	INPUT REGISTER	OUTPUT REGISTER
00	Counter 0	Counter 0
01	Counter 1	Counter 1
02	Counter 2	Counter 2
03	Unused	Counter 0-2 control
10	Counter 3	Counter 3
11	Counter 4	Counter 4
12	Counter 5	Counter 5
13	Unused	Counter 3-5 control
2X	Interrupt status	Interrupt clear
4X	Measurement status	Channel 0-1 measurement control
5X	Decade switch	Channel 2-3 measurement control
6X	Function switch	Channel 4-5 measurement control
7X	UART receive register	UART transmit register

The two input/output ports of the microcomputer are used for additional status and control lines. These signals are listed in Table 167-3.

Table 167-3. Microcomputer U28 Port Signals

BIT	PORT 1 SIGNAL (ACTIVE STATE)	PORT 2 SIGNAL (ACTIVE STATE)
0	UART error (H)	Unused
1	UART TRE (H)	Unused
2	UART TBRE (H)	Unused
3	UART interrupt enable (L)	Unused
4	Serial link driver enable (L)	Function control 0-1 (H = Frequency)
5	Unused	Function control 2-3 (H = Frequency)
6	Unused	Function control 4-5 (H = Frequency)
7	Unused	Unused

CLOCK GENERATOR

The clock generator section, shown in Figure 167-5, uses a chain of counters to divide the 10-MHz clock from oscillator Y1 into the other clocks needed on the assembly. The debounce period switch selects the frequency for the debouncer clock and for the test clock available at terminal 1 on the rear panel connector.

COUNTERS AND MEASUREMENT CONTROL SECTION

A simplified schematic of the counters and measurement control section is shown in Figure 167-6. The measurement control circuitry for each pair of channels is identical.
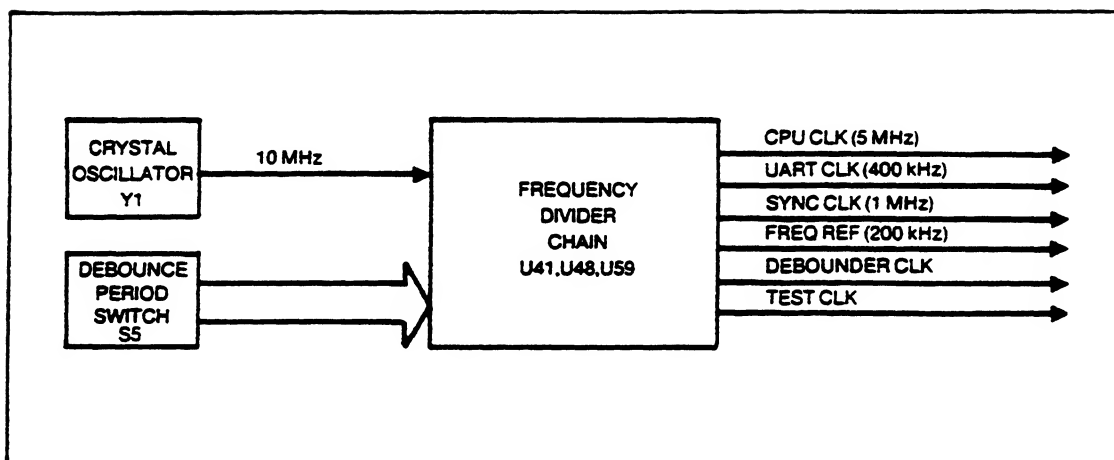
Figure 167-5. Clock Generator Block Diagram
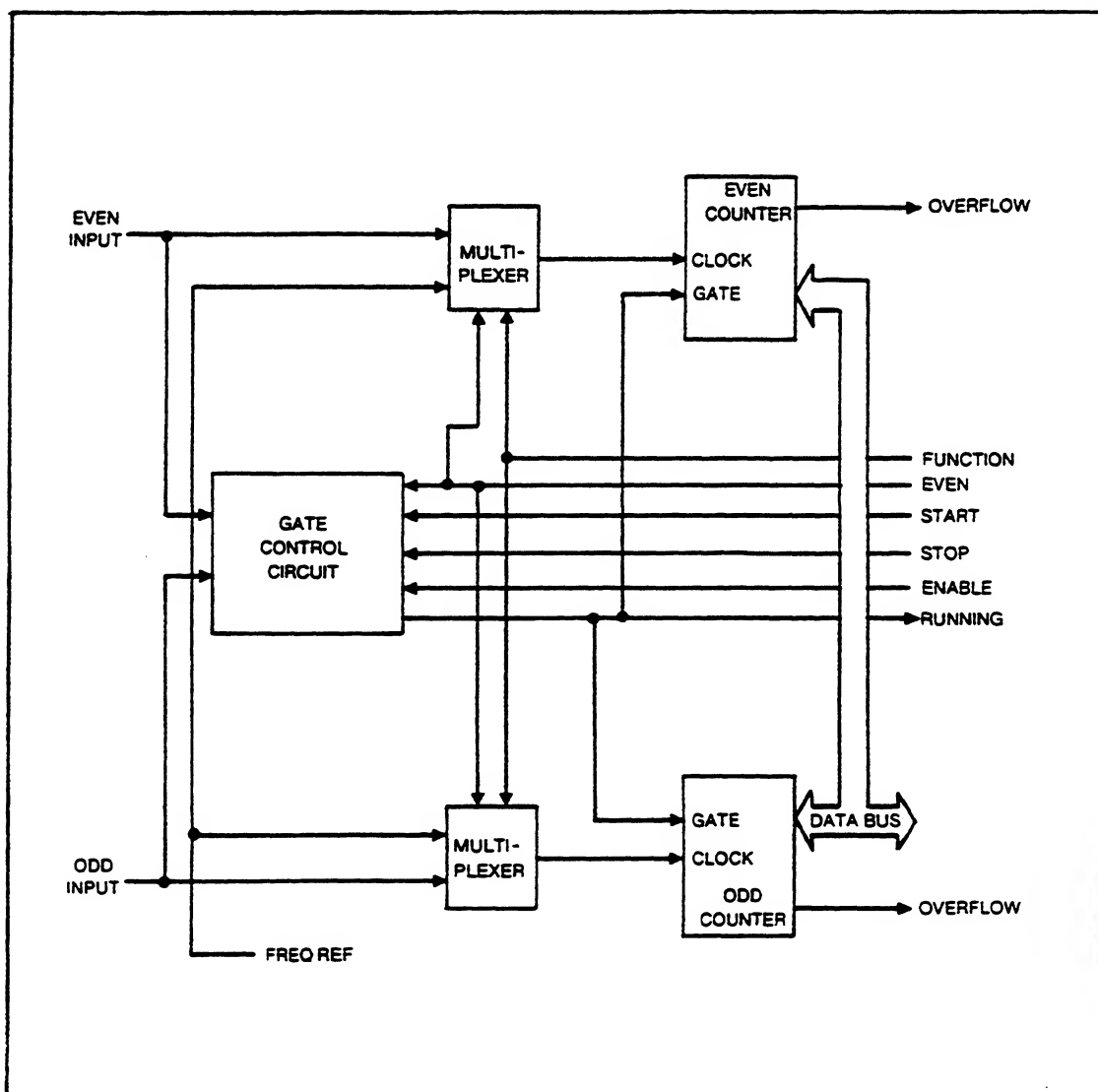
Figure 167-6. Measurement Control for a Pair of Channels, Simplified Schematic

The microcomputer uses five signals to control this section. The FUNCTION line determines whether an event counting or frequency measurement will occur. The EVEN line selects the channel, either even or odd, for frequency measurement. The START signal forces the counter gates open, allowing the counters to run. The STOP signal forces the counter gates closed. The ENABLE line allows, but does not force, the gates to open or close. Once enabled, the gates will open or close on the next input signal trigger.

Three signals are used to monitor this section. The RUNNING signal controls the counter gates and informs the microcomputer that the counters are running. The two OVERFLOW signals cause interrupts to the microcomputer when the counters overflow.

For event counting, the microcomputer selects the count function and forces the counters to start. With the even channel selected, the even and odd counters are driven by their respective input signals. With the odd channel selected, both counters are driven by the frequency reference clock. This mode is not used in normal operation.

For frequency measurements, the microcomputer selects the frequency function and enables the counters to start. With the even channel selected, the even counter counts triggers of the even input and the odd channel counts reference clocks. With the odd channel selected, the odd counter counts triggers of the odd input and the even channel counts reference clocks. The counters start running on the next trigger of the selected input signal. After the sample time (about 2/3 second), the microcomputer toggles the ENABLE signal. The counters stop running on the next input trigger. After completing a measurement on one channel, the microcomputer selects the other channel in the pair and repeats the process.

INPUT CONDITIONERS

Figure 167-7 shows a simplified schematic of the input conditioners. As shown in Figure 167-8, each input conditioner consists of several stages. The first stage clamps the input voltage to prevent damage to the Counter/Totalizer circuitry. Any input signal exceeding about 12 volts will be clamped. The comparator stage detects input voltage transitions and rejects noise. The comparator thresholds are determined by the reference voltage and deadband adjustments. The level converter shifts the comparator output signal to CMOS logic levels.

Figure 167-9 illustrates debouncer operation. When the debouncer is switched in, the input signal must remain stable longer than the debounce period before a new input level will be recognized. Three debounce times are available: 4 ms, 20 ms, and 80 ms. They are selected by the debounce period switch.

The final input conditioner stage is the synchronizer. This stage synchronizes the input signals to the Counter/Totalizer clocks to guarantee that the counter setup and hold times are satisfied.
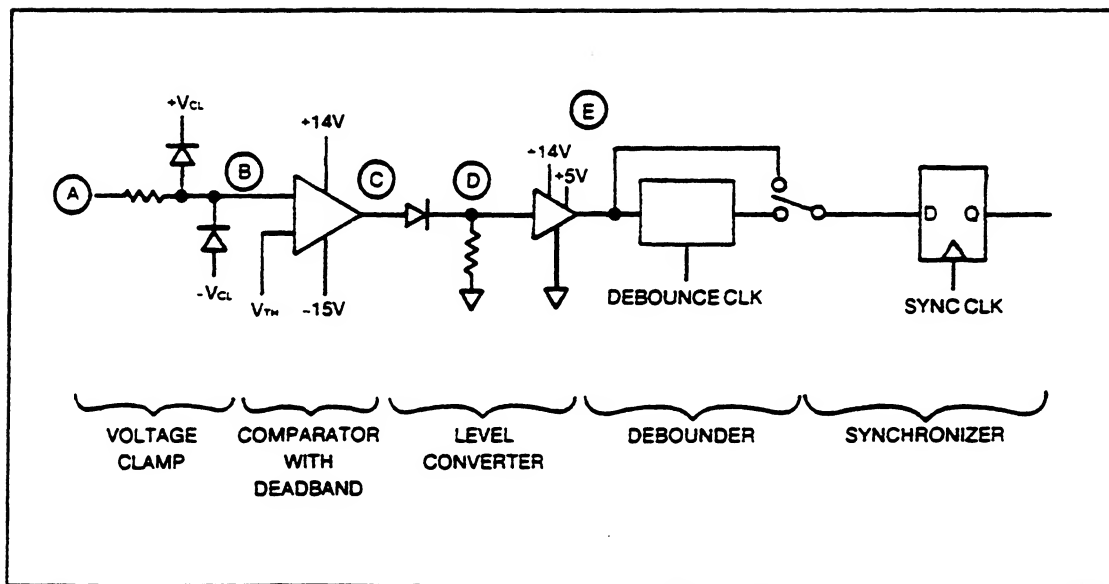
Figure 167-7. Input Conditioner, Simplified Schematic
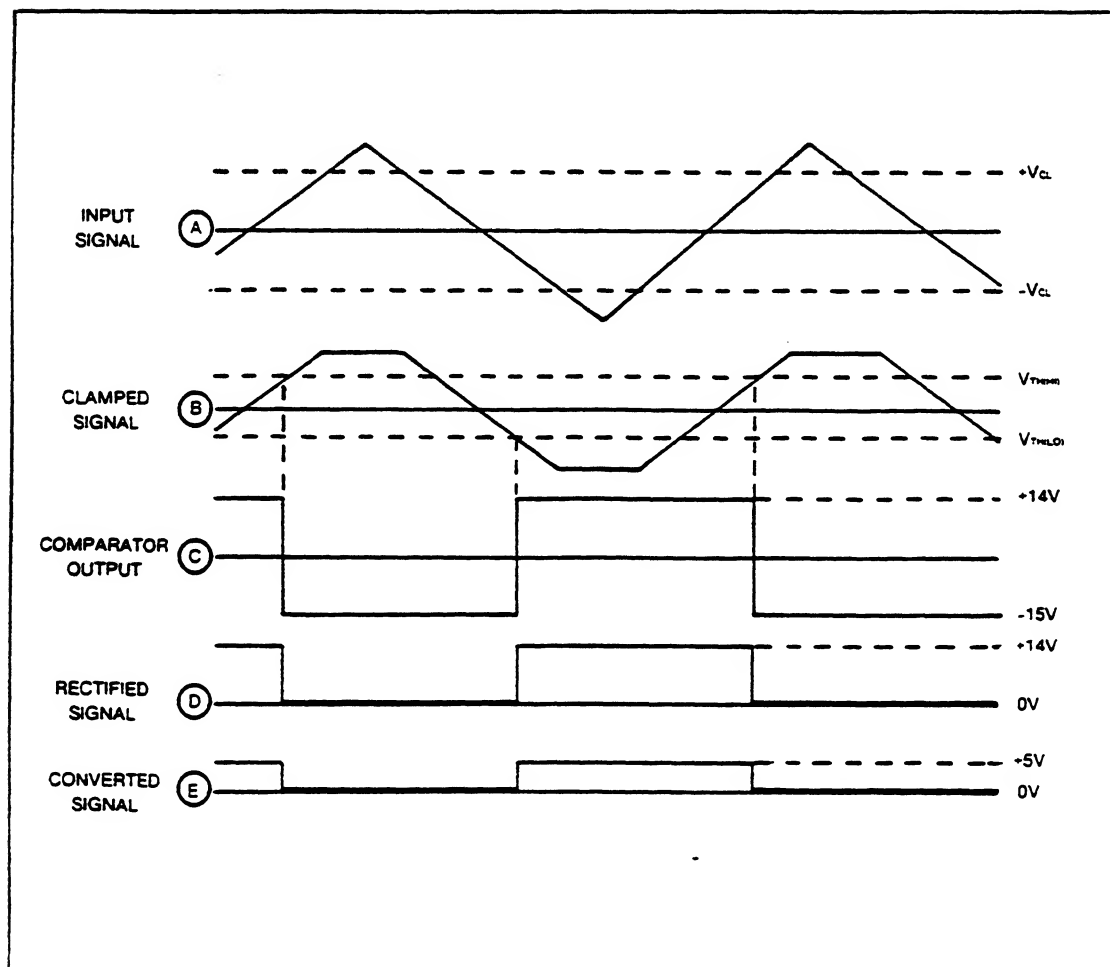
Figure 167-8. Input Conditioner Operation
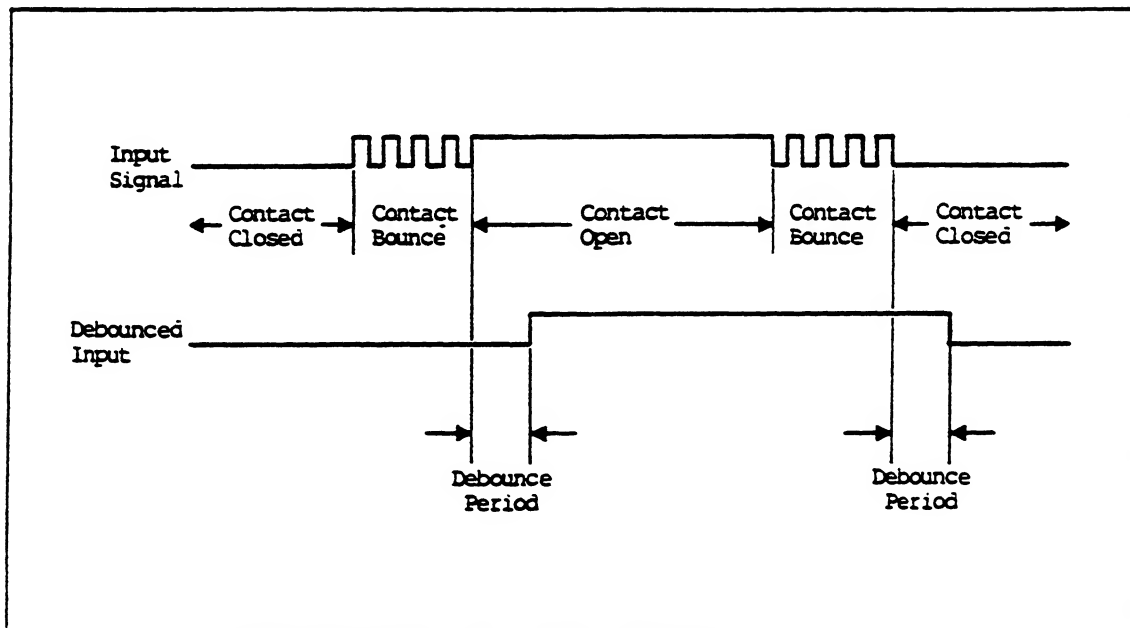
Figure 167-9. Debouncer Operation

GENERAL MAINTENANCE

The Counter/Totalizer assembly should be cleaned if dirt, dust, or other contamination is visible on the surface. Follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THIS EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURE.

Five performance tests are used to verify that the Counter/Totalizer assembly is operating properly. These tests, listed below, can be performed individually, for a partial performance evaluation, or in sequence for a complete test:

o   Channel Selection Test

o   Reference Voltage Test

o   Deadband Adjustment Test

o   Frequency Test

o   Event Counting Test

)

ACCESSING COUNTER/TOTALIZER SWITCHES

To perform these tests, it is necessary to set switches on the
Counter/Totalizer that are not accessible through the rear panel. These
switches can be made accessible in three ways:

Alternative 1

Install a Calibration/Extender Fixture (Fluke P/N 648741) in a
Front End option slot, and install the Counter/Totalizer assembly
on the fixture. Ensure that the switch on the fixture is set to
EXTEND position.

With this method, the switches on the Counter/Totalizer assembly
are accessible at all times.

Alternative 2

If a Calibration/Extender Fixture is not available, remove all
other option assemblies from the Front End and install the
Counter/Totalizer assembly in the bottom slot.

In this configuration, the switches can be reached without using an
extender.

Alternative 3

If neither of the previous alternatives is feasible, disconnect
power and slide the Counter/Totalizer assembly out of the Front End
to reach the switches. Reinstall the assembly and reconnect power
to continue testing.

NOTE

The Counter/Totalizer's operating program resides
in an EPROM. This EPROM may be either a 2716
installed in U57 or a 2732 installed in U49.
Ensure that switch S2-1 is set to the position
appropriate for the EPROM installed at the
factory.

The locations of Counter/Totalizer switches and adjustments are shown in
Figure 167-10.

DEBOUNCED/DIRECT
INPUT
(ONE PER CHANNEL)

FIXED/VARIABLE
REFERENCE
(ONE PER CHANNEL)

TTL/0V
FIXED
REFERENCE

FUNCTION
SWITCHES
(ONE PER
CHANNEL PAIR)

TEST CLOCK/
DEBOUNCE
PERIOD

CHANNEL
DECADE

FLOATING/
PULLED UP
INPUTS

DEADBAND
ADJUST
(ONE PER
CHANNEL)

VARIABLE REF ADS

TOP VIEW
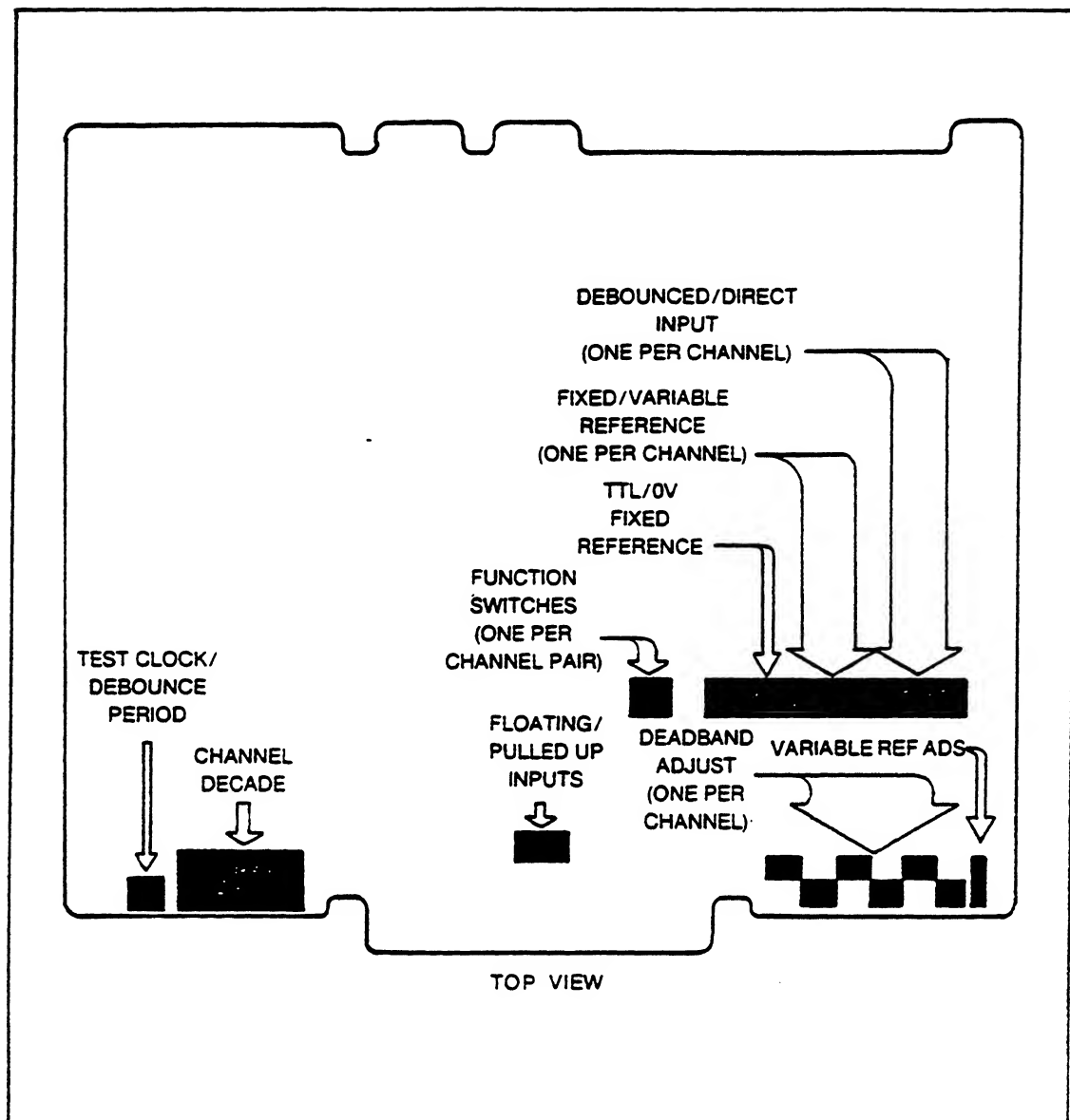
Figure 167-10. Counter/Totalizer Switches and Adjustments

Channel Selection Test

The Channel Selection Test verifies that the Counter/Totalizer channel
decade is selectable. To conduct the
Channel selection test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power
    cord and all other high voltage inputs.

2. Remove all other installed options to eliminate addressing conflict.

3. Note the setting of the function switches on the Counter/Totalizer assembly. Install the assembly in the Front End.

4. Set the Counter/Totalizer channel decade switches to position 00.

5. Reconnect the ac line cord to the Front End, and switch the power ON.

6. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

    MODE=TERM <CR>

    RESET CHAN(0..5) <CR>

    LIST CHAN(0..5) <CR>

Verify that a listing for all designated channels is returned. The response should be either:

    ctchan(channel number)=count

            or

    ctchan(channel number)=freq

The type function, (COUNT or FREQ) should agree with the setting of the function switch for the specified pair of channels.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to perform the required tests on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

    Th:se programs are offered as examples. If you do
    no: have an IBM PC or a Fluke 1722A Instrument
    Controller, enter a program that will run on your
    host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"reset chan(0..5)"
100   GOSUB 300
110   REM obtain hardware configuration
120   PRINT #1,"list chan(0..5)"
130   FOR I=0 TO 6
140   LINE INPUT #1,M$
150   PRINT M$;
160   NEXT I
200   END
300   REM wait for message accepted prompt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1%
50    OPEN "KB1:"AS OLD FILE 2%
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"reset chan(0..5)"
110   GOSUB 300
120   REM obtain hardware configuration
130   DIM L$(7)
140   PRINT #1,"list chan(0..5)"
150   FOR I%=0 TO 6\INPUT LINE #2,L$(I%)\NEXT I%
160   X%=0
170   PRINT L$(X%)
180   X%=1
190   PRINT L$(X%)\X%=X%+1
200   IF X%>6 THEN 220
210   GOTO 190
220   END
300   REM wait for message accepted prompt
```

```
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

A listing of the definitions for all six channels should be returned. The top line returned will be a number indicating the number of channel definitions to follow. The response should be:

```
6
0,4,0,0,0,0
     .
     .
     .
     .
5,4,0,0,0,0
```

NOTE

The number in field 3 may be either 0 (for COUNT function) or 1 (FREQ), depending on the function switch setting.

7. Set channel decade switches on the the Counter/Totalizer to 01.

8. Program the Front End to list its hardware configuration for channels 10 through 15.

   To do this, substitute channels 10 through 15 for channels 0 through 5 in both the RESET CHAN and LIST CHAN commands of step 6.

9. Repeat steps 7 and 8 for switch settings 02 (channels 20 through 25), 04 (channels 40 through 45), 08 (channels 80 through 85), 10 (channel 100 through 105), 20 (channels 200 through 205), 40 (channels 400 through 405) and 80 (channels 800 through 805).

10. This completes the Channel Selection Test.

Reference Voltage Test

This Reference Voltage Test verifies that the 0V and TTL fixed reference voltages are within tolerance, that the variable reference is fully adjustable, and that both the fixed and variable reference voltages can be selected for each channel.

To conduct the Reference Voltage Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install the Counter/Totalizer assembly in the Front End.

3. Reconnect the ac line cord to the Front End, and switch the power ON.

4. Connect digital multimeter (DMM) test leads to the variable reference terminal and to one of the return terminals on the Counter/Totalizer input connector.

5. Using a small screwdriver, turn the variable reference adjustment screw counterclockwise until the DMM displays negative 10.00V +/- 0.10V. Then turn the screw clockwise until the DMM displays positive 10.00 +/- 0.10V.

6. Turn the deadband adjustment screw for each channel counterclockwise until it stops. Move the fixed/variable reference switch for each channel to the VARIABLE REFERENCE position.

7. By connecting the DMM test leads to the appropriate threshold output and return terminals on the Counter/Totalizer input connector, verify that the threshold voltage for each channel is between 9.80 and 10.20V.

8. Move the fixed/variable reference switch for each channel to the FIXED REFERENCE position. Move the 0V/TTL fixed reference switch to the 0V position.

9. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between -0.10V and 0.10V.

10. Move the 0V/TTL fixed reference switch to the TTL position.

11. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between 1.30 and 1.50V.

12. This completes the Reference Voltage Test.

Deadband Adjustment Test

The Deadband Adjustment Test verifies that the deadband is fully adjustable for each channel.

To conduct the Deadband Adjustment Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install the Counter/Totalizer assembly in the Front End.

3. Reconnect the ac line cord to the Front End. Switch the power ON.

4. Using a jumper wire, connect the test clock output terminal on the Counter/Totalizer connector to each of the six input terminals. Install the connector on the Counter/Totalizer assembly.

5. Using a small screwdriver, move the test clock switch to position 0 (+14V output).

6. Move the fixed/variable reference switch for each channel to the FIXED REFERENCE position. Move the OV/TTL fixed reference switch to the OV position.

7. Using a small screwdriver, turn the deadband adjustment screw for each channel counter-clockwise until it stops.

8. Connect the DMM test leads to the appropriate threshold output and return terminals on the Counter/Totalizer input connector, and verify that the threshold voltage for each channel is between -0.04V and 0.04V.

9. For each channel, turn the deadband adjustment clockwise until it stops.

10. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between -1.20V and -1.80V.

11. This completes the Deadband Adjustment Test.

Frequency Test

The Frequency Test checks the frequency measurement function for each channel. Measurement accuracy and underrange detection are tested.

To conduct the Frequency Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Move all of the function switches on the Counter/Totalizer assembly to the FREQ position. Move all of the debounced/direct input switches to the DIRECT INPUT position. Install the assembly in the Front End.

3. Set the channel decade switches to 00.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Using a small screwdriver, move the test clock switch to position 2 (100 KHz).

6. Using a jumper wire, connect the test clock output terminal on the Counter/Totalizer connector to each of the six input terminals. Install the connector on the Counter/Totalizer assembly.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..5)=FREQ <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0..5) <CR>
```

The returned channel readings should be 1.00000E+05 Hz (100 kHz) within a tolerance of 10 Hz.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a frequency measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
120 PRINT #1,"def chan(0..5)=freq"
```

```
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0..5)"
180 FOR I=0 TO 5
190 INPUT #1,M$
200 PRINT "chan";I;"=";
210 PRINT M$;
220 PRINT " hertz"
230 NEXT I
240 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:" AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..5)=freq"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT #1,"send chan(0..5)"
180  FOR I%=0 TO 5
190  INPUT #2,M$
200  PRINT "chan";I%;"=";
210  PRINT M$;
220  PRINT " hertz"
230  NEXT I%
250  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The returned channel readings should be 1.00000E+05 Hz (100 kHz)
within a tolerance of 10 Hz.

8. Move the test clock switch to position 1 (-15 VDC output) and take another measurement from channels 0 through 5.

    If you are in the Terminal Mode, take these measurements by entering:

        SEND CHAN(0..5) <CR>

    If you are in the Computer Mode, run the program entered in step 7.

    Verify that 9.999999E+37 (a fault indication reading) is returned for each channel.

9. Perform PROCEDURE 9A or PROCEDURE 9B as appropriate.

PROCEDURE 9A. TERMINAL MODE

Send the following command to inspect the fault condition:

    LIST ERROR <CR>

The error displayed for the selected channels should show:

    Out of range

PROCEDURE 9B. COMPUTER MODE

The following are BASIC programs for the IBM PC and 1722A, respectively. Run one of these programs "as is" or make the modifications necessary to run on your host.

Program for IBM PC:

```
10  CLS
20  REM send the fault condition
30  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40  PRINT #1,"list error"
50  INPUT #1,N
60  PRINT N
70  IF N=0 THEN 120
80  FOR I=1 TO N
90  LINE INPUT #1,E$
100 PRINT E$
110 NEXT I
120 END
```

Program for 1722A:

```
10  PRINT CHR$(27);"[2J";
20  REM send the fault condition
30  PRINT #1,"list error"
```

```
40   INPUT #2,N
50   PRINT N
60   IF N=0 THEN 110
70   FOR I=1 TO N
80   INPUT LINE #2,E$
90   PRINT E$
100 NEXT I
110 END
```

The displayed response should be:

```
6
0,15
1,15
2,15
3,15
4,15
5,15
```

The number "6" on the first line indicates that six errors were logged. The pairs of numbers that follow indicate, first, the channel number, then, the error number. Error 15 is: "?Out of Range".

10.   This completes the Frequency Test.

Event Counting Test

The Event Counting Test checks the event counting function for each channel. Measurement accuracy and overrange detection are tested.

To conduct the Event Counting Test, perform the following procedure:

1.   Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2.   Move all of the function switches on the Counter/Totalizer assembly to the COUNT position.

3.   Move all of the debounced/direct input switches to the DIRECT INPUT position.

4.   Install the Counter/Totalizer in the Front End. Be sure that the channel decade switches are set to "00".

5.   Reconnect the ac line cord to the Front End and switch the power ON.

6.   Using a small screwdriver, move the test clock switch to position 3 (50 Hz W/BOUNCE).

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

    Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

        MODE=TERM <CR>

        DEF CHAN(0..5)=TOTAL <CR>

        FORMAT=DECIMAL <CR>

        SEND CHAN(0..5) <CR>

Ignore the initial measurement response. As close as possible to 20 seconds after the first SEND CHAN command is executed, send another

        SEND CHAN(0..5) <CR>

command to the Front End.

A count of approximately 9000 (9.00000E+03) +/- 100 should be returned.

NOTE

>   The second SEND CHAN command returns the count
>   accumulated since the first SEND CHAN command.
>   Each additional SEND CHAN command returns only the
>   counts since the previous SEND CHAN command.
>   Timing is critical in performance of this test.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a totalizing measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

>   These programs are offered as examples. If you do
>   not have an IBM PC or a Fluke 1722A Instrument
>   Controller, enter a program that will run on your
>   host.

Program for IBM PC:

```
10   CLOSE 1
20   PLAY "mf"
30   CLS
40   REM open communication port and empty Front End buffer
50   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
60   PRINT #1,CHR$(3);
70   REM set up Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..5)=total"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT "1,"send chan(0..5)"
175  FOR I=0 TO 5
180  INPUT #1,M$
190  PRINT "chan";I;"=";
200  PRINT M$;
210  PRINT " events"
220  NEXT I
230  SOUND 32767,364
240  PRINT TIME$
250  GOTO 170
260  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:" AS NEW FILE 1%
50   OPEN "KB1:" AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..5)=total"
130  GOSUB 300
140  PRINT #1,"format=decimal"
```

```
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0..5)"
180 T=TIME
190 FOR I=0 TO 5
200 INPUT #2,M$
210 PRINT "chan";I;"=";
220 PRINT M$;
230 PRINT " events"
240 NEXT I
250 WAIT 19770
260 T=TIME-T
270 PRINT\PRINT T/1000;" second interval"
280 GOTO 170
290 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Ignore the first set of readings. Each additional set of readings (taken every 20 seconds) should respond with a count of 9000 (9.00000E+03) +/- 100 counts.

NOTE

The second SEND CHAN command will return the count accumulated since the first SEND CHAN command. Each additional SEND CHAN command returns only the counts since the previous SEND CHAN command. Timing is critical in performance of this test.

8. Move all of the debounced/direct input switches to the DEBOUNCED INPUT position. Repeat step 7 to take more measurements.

    Ignore the first set of readings. Each additional measurement should respond with a count of 1000 (1.00000E+03) +/- 25 on channels 0 through 5.

9. This completes the Event Counting Test.

CALIBRATION

The Counter/Totalizer needs no special calibration, but it must be properly configured and adjusted before making measurements.

The setup procedures for the Counter/Totalizer are determined by the type of measurement to be taken. Refer to the Helios I System Manual for frequency (Section 6d) and totalizing (Section 6k) measurement setup instructions.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Counter/Totalizer assembly is provided in Table 167-7.

For parts ordering information, see Section 6 of this manual.

Figure 167-11 is a schematic diagram of the Counter/Totalizer.

TABLE 167-7. COUNTER/TOTALIZER PCA
(SEE FIGURE 167-11.)

REFERENCE DESIGNATOR A->NUMERICS---> S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
R 58	RES.MF.15K,+-1%,0.125W,100PPM	285296	91637	CMF551502F	1		
R 64, 66, 69,	RES.CF.51K,+-5%,0.25W	376434	80031	CR251-4-5P51K	6		
R 72, 75, 86		376434					
R 65, 67, 70,	RES.CF.6.2K,+-5%,0.25W	442368	80031	CR251-4-5P6K2	6		
R 73, 76, 85		442368					
R 81, 82	RES.CF.5.1K,+-5%,0.25W	368712	80031	CR251-4-5P5K1	2		
R 83,101-112	RES.CF.2K,+-5%,0.25W	441469	80031	CR251-4-5P2K	13		
R 84	RES.CF.180,+-5%,0.25W	441434	80031	CR251-4-5P180E	1		
R 88- 93	RES.CF.150K,+-5%,0.25W	348938	80031	CR251-4-5P150K	6		
R 94	RES.MF.100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	1		
R 95	RES.MF.32.4K,+-1%,0.125W,100PPM	182956	91637	CMF553242F	1		
R 96	RES.MF.1.4K,+-1%,0.125W,100PPM	344333	91637	CMF551401F	1		
R 97	RES.MF.12.7K,+-1%,0.125W,100PPM	217448	91637	CMF551272F	1		
R 98	RES.MF.866,+-1%,0.125W,100PPM	248641	89536	248641	1		
R 113-115,117-	RES.VAR.CERM.20K,+-10%,0.5W	291609	89536	291609	6		
R 119		291609					
R 116	RES.VAR.CERM.25K,+-20%,0.5W	285213	11236	190PC253B	1		
S 1	SWITCH.MODULE.SPST.DIP.4 POS	408559	00779	435166-2	1		
S 2- 4	SWITCH.MODULE.SPDT.DIP.5 POS	417766	00779	435470-4	3		
S 5	SWITCH.MODULE.BCD.DIP.10 POS	643585	89536	643585	1		
S 6	SWITCH.ROTARY.1 POLE.16 POS.1 THUMB	615096	97527	1A-21-60-33-G-F	1	5	
S 7	SWITCH.ROTARY.1 POLE.10 POS.1 THUMB	602888	97527	1A-21-60-02-G-F	1		
T 1	INVERTER.TRANSFORMER	716209	89536	716209	1		
TM 1	TECHNICAL DATA SHEET # 80127	530303	89536	530303	1		
U 2	• IC.BFLR.DUAL DIFF LINE DRVR W/3-STATE	586081	12040	DS1692J	1	1	
U 3	• IC.BPLR.DIFFERENTIAL LINE RECEIVER	586073	01295	SN55182J	1	1	
U 4	• ISOLATOR.OPTO.HI-SPEED.DUAL	429894	28480	5082-4355	1	1	
U 5, 9	• ISOLATOR.OPTO.HI-SPEED.8 PIN DIP	354746	89536	354746	2	1	
U 6	• IC.REGULATING PULSE WIDTH MODULATOR	454678	01295	SG3524N	1	1	
U 7	• IC.CMOS.HEX INVERTER	381848	02735	CD4049AE	1	1	
U 8	• IC.VOLT REG.FIXED.+15 VOLTS,0.1 AMPS	453035	04713	MC78L15ACG	1	1	
U 10, 14	• IC.OP AMP.DUAL.INDUSTRIAL TEMP RANGE	605550	01295	LM258JG	2	1	
U 11	• IC, 2.5 V,40 PPM T.C.,BANDGAP REF	472845	04713	MC1403V	1	1	
U 12, 62- 64	• IC.COMPARATOR.DUAL.INDUSTRIAL TEMP	741785	89536	741785	4	1	
U 13	• IC, 1.22V,100 PPM T.C.,BANDGAP REF	452771	89536	452771	1	1	
U 15, 38, 42	• IC.LSTTL.QUAD 2 INPUT OR GATE	605618	01295	SN54LS32J	3	1	
U 16, 23, 50,	• IC.CMOS.HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	4	1	
U 55	•	407759					
U 17, 43	• IC.CMOS.PROGRAMMABLE INTERVAL TIMER	723643	89536	723643	2	1	
U 18	• IC.CMOS.HEX D F/F.+EDG TRG.W/RESET	404509	12040	MM74C174N	1	1	
U 19, 24, 45	• IC.CMOS.DUAL D F/F.+EDG TRG W/SET&RST	536433	04713	MC4013BCP	3	1	
U 20, 22	• IC.CMOS.HEX SCHMITT TRIGGER	723320	89536	723320	2	1	
U 21, 25	• IC.FTTL.DUAL D F/F.+EDG TRG.W/CL&SET	659508	07263	74F74PC	2	1	
U 27	• IC.CMOS.TRIPLE 2-1 LINE MUX/DEMUX	375808	02735	CD4053BE	1	1	
U 28	IC. NMOS. 8 BIT MICROCOMPUTER	685529	89536	685529	1	1	
U 29	IC. CMOS. UNIV ASYNC RECEIVR/TRANSMIT	453464	32293	IM6402CPL	1	1	
U 30, 36, 44	• IC.CMOS.QUAD D LATCH.+EDG TRG.W/RESET	412742	12040	MM74C173N	3	1	
U 31	• IC.CMOS.TRIPLE 3 INPUT AND GATE	408807	02735	CD4073BE	1	1	
U 32- 34, 54	• IC.CMOS.DUAL 4-1 LINE MUX/DMUX ANL SW	429886	02735	CD4052BE	4	1	
U 35	• IC.LSTTL.HEX INVERTER	393058	01295	SN74LS04N	1	1	
U 37	• IC.CMOS.TRIPLE 3 INPUT OR GATE	408575	02735	CD4075BE	1	1	
U 39, 40	• IC.LSTTL.HEX D F/F.+EDG TRG.W/CLEAR	393207	01295	SN74LS174N	2	1	
U 41	• IC.LSTTL.DUAL DIV BY 2.DIV BY 5 CNTR	483594	01295	SN74LS390N	1	1	
U 46	• IC.CMOS.HEX BUFFER	355412	02735	CD4010AE	1	1	
U 47	• IC.CMOS.HEX CONTACT BOUNCE ELIMINATOR	536557	04713	MC14490VP	1	1	
U 48, 59	• IC.CMOS.DUAL BCD UP COUNTER	386227	04713	MC14518BCP	2	1	
U 51	• IC.CMOS.QUAD XOR GATE	586727	04713	MC14077BCP	1	1	
U 52	• IC.TTL.QUAD 2 INPUT AND GATE	393066	01295	SN74LS08N	1	1	
U 53	• IC.LSTTL.BCD-DECIMAL 4-10 LINE DCDR	408716	01295	SN74LS42N	1	1	
U 56	• IC.LSTTL.OCTAL D F/F.+EDG TRG.W/CLEAR	454892	01295	SN74LS273N	1	1	
U 57	IC. 2K X 8 EPROM. PROGRAMMED	747964	89536	747964	1		
U 58, 65	• IC.OP AMP.JFET INPUT.8 PIN DIP	472779	12040	LF386N	2	1	
U 60, 61	• IC.ARRAY.16 DIODE.8 COM CATH.8 COM AN	536235	89536	536235	2	1	
VR 1	• ZENER.UNCOMP.6V TRANSIENT SUPPRESSOR	508655	24444	1N5908	1	3	
VR 2	• ZENER.UNCOMP. 20.0V, 5%, 12.5MA, 1.0W	291575	12969	UZ8720	1	1	
VR 3, 4	• ZENER.UNCOMP. 12.0V, 5%, 10.5MA, 0.4W	249052	04713	1N963B	2	1	
XU 28, 29	SOCKET.IC.40 PIN	429282	09922	DIL840P-108	2		
XU 57	SOCKET.IC.24 PIN	376236	91506	324-AG39D	1		
XZ 1, 8	SOCKET.IC.16 PIN	276535	91506	316-AG39D	2		
Y 1	OSCILLATOR.10.0MHZ.TTL CLOCK	723767	89536	723767	1		
Z 1- 7	RES.NET.SIP.10 PIN.9 RES.10K,+-2%	414003	80031	95081002CL	7		
Z 8	RES.NET.SIP.8 PIN.7 RES.10K,+-2%	412924	80031	95081002CL	1		

DESCRIPTION

The -168 Digital I/O Assembly (shown in Figure 168-1) allows the Front End to receive and transmit digital information.

The input connector used and the way the connector is wired determine whether the assembly is used by the Front End to transmit or receive information. When used for output, a single channel (or single bit) can be changed at a time. When used for input, the Front End can read a single bit at a time or parallel words in a binary or binary-coded-decimal (bcd) format.

Two connector options are available with the Digital I/O Assembly: the -169 Status Output Connector for output and the -179 Digital/Status Input Connector for input. Signals originating on the connector inform the Digital I/O Assembly whether it is being used for input or output. The Digital I/O Assembly supports 20 input or output channels.

If the Digital I/O Assembly is used to input data to the Front End, two additional input lines are used to determine which information type (bcd, binary, or status) the assembly is to measure. Refer to the appropriate connector option section in the Helios I System Manual for configuration instructions.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Digital I/O Assembly theory of operation, performance tests, a parts list, and schematic diagrams.

Installation, operating, and system configuration instructions are found in the Helios I System Manual.

Option specifications are found in the appendices of this manual and in the System Manual.

Equipment required for the procedures in this subsection is listed in Table 168-1. A summary of test equipment required for all procedures in this manual is given in Table 2-2 in Section 2 of this manual.
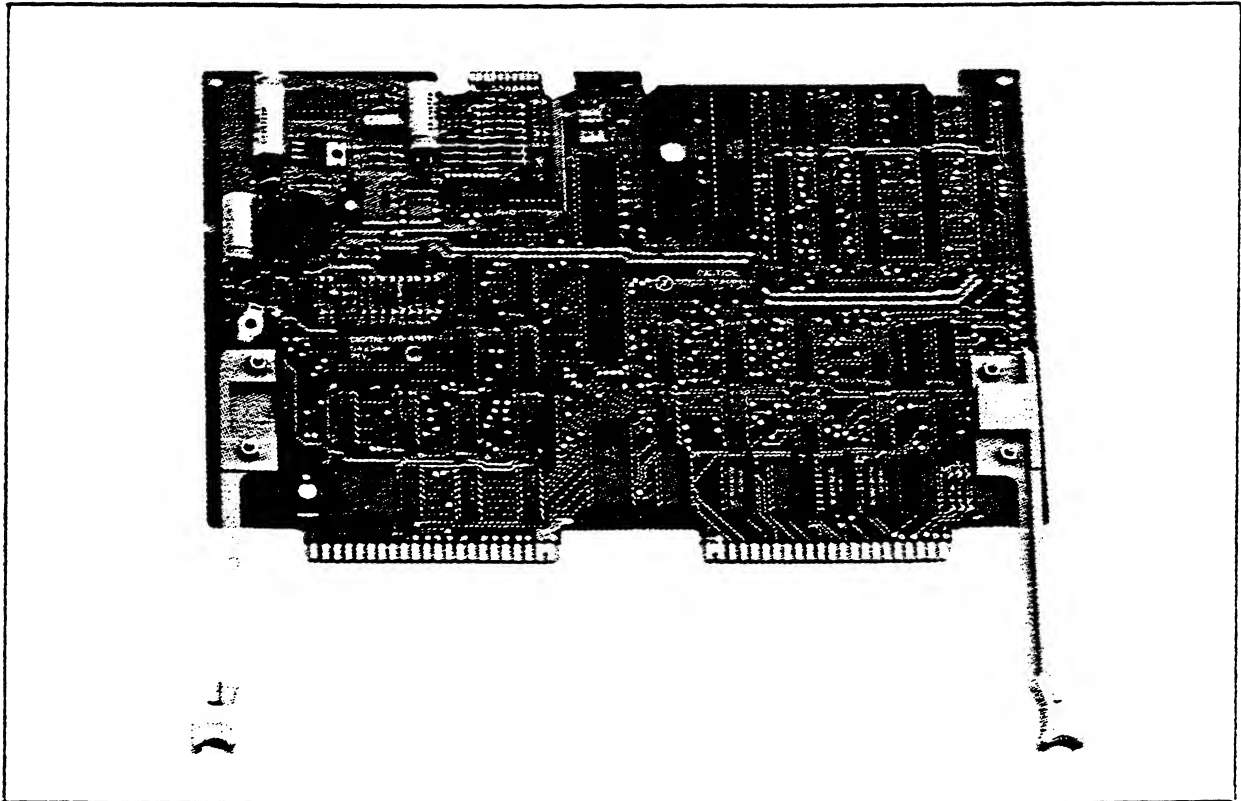
Figure 168-1. Digital I/O Assembly

Table 168-1. Required Test Equipment for -168

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DMM	Capable of measuring +12V	Fluke 77
Calibration/ Extender Fixture	NA	Fluke Accessory Part No. 648741 (no substitute)
Digital/Status Input Connector	NA	Fluke Option -179 (no substitute)
Status Output Connector	NA	Fluke Option -169 (no substitute)
Power Supply	Capable of sourcing +12V dc	Appropriate lab type
Resistor, 2ea.	220 ohms, 1W	Fluke Part No. 109462
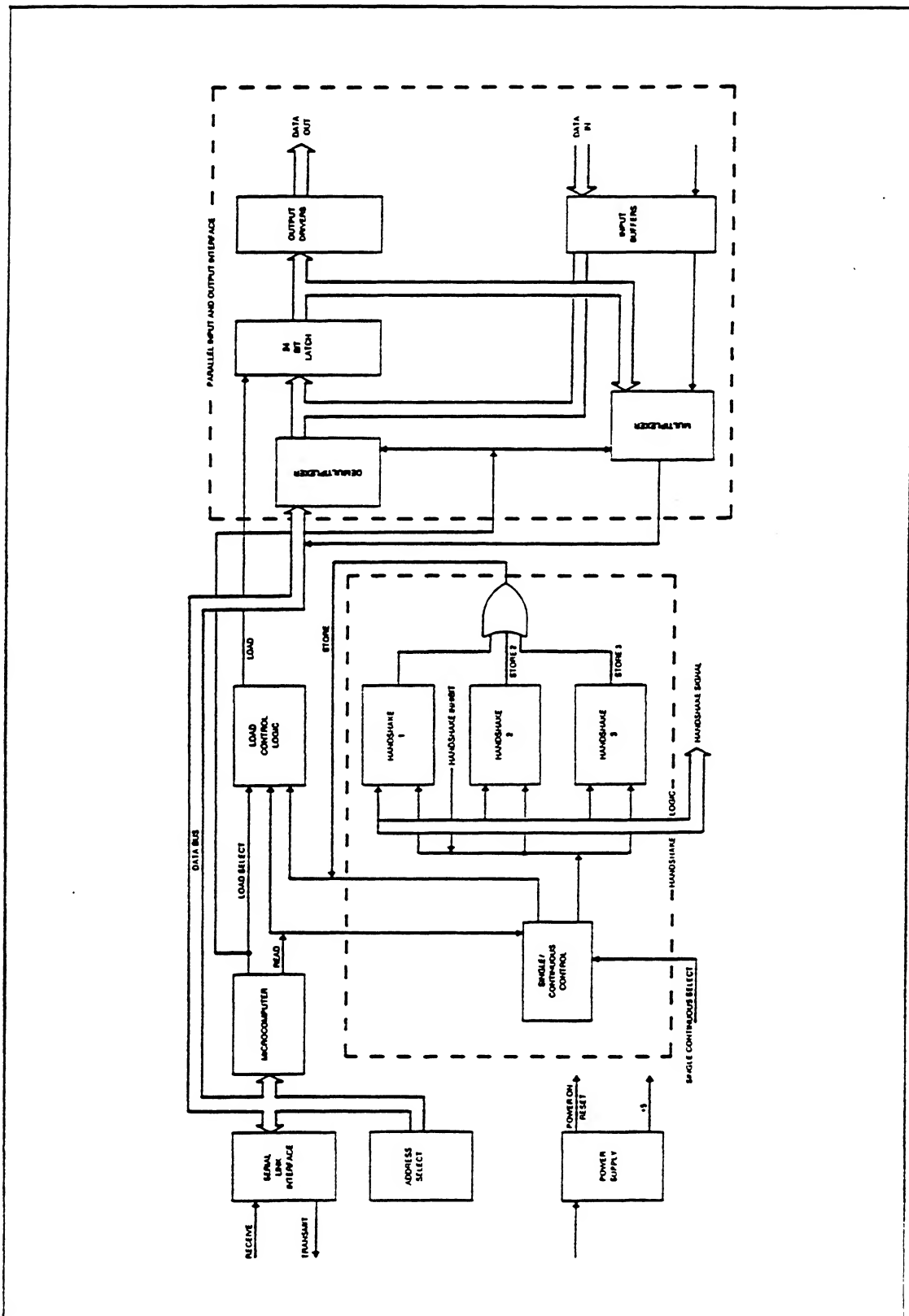
Figure 168-2. Digital I/O Assembly Block Diagram

THEORY OF OPERATION

The theory of operation for the Digital I/O Assembly includes: a functional description, a block diagram analysis (which describes how each major circuit block on the Digital I/O Assembly works), and an analysis of each circuit block.

Where necessary, block diagrams and simplified schematics are included with the text. Schematic diagrams for the Digital I/O Assembly are at the end of this option subsection.

Overall Functional Description

The Digital I/O Assembly allows the Front End to output single-bit alarm or status information and the ability to input information in any of three formats: single-bit alarm or status, bcd-formatted digital, and binary-formatted digital information.

Block Diagram Analysis

The Digital I/O Assembly contains six major circuit blocks (shown in Figure 168-2): the power supply, address select, the serial link interface, the microcomputer, the handshake logic, and the parallel input and output interfaces. The following paragraphs discuss the function of each of these circuit blocks.

POWER SUPPLY

The power supply converts incoming dc power from the serial link into isolated +5V dc for the Digital I/O circuitry and +5V dc for the serial link. The power supply circuitry also generates a reset signal that is used to start up the the microcomputer and the handshake logic properly.

SERIAL LINK

The Serial Link allows the Digital I/O Assembly to exchange commands and measurement data with the Front End mainframe controller. In this block, the bi-directional serial transmissions are electrically isolated, buffered, and converted to signals that the microcomputer can use. The serial link circuitry sends an interrupt signal and data to the microcomputer while the microcomputer returns data and a transmitter enable signal.

ADDRESS SELECT

Two thumbwheel switches on the Digital I/O Assembly are used to select the channel range for the assembly. The switches select the starting channel number of a block of 20 contiguous channels for the assembly. The switch that selects the most significant digit has a valid range of 0 to 14 (position 15 not used), and the switch that selects the second-most significant digit has a range of 0 to 9.

MICROCOMPUTER

The Digital I/O Assembly uses an NMOS 8748, 8-bit microcomputer to control all interaction between the Front End mainframe controller and the input/output interface.

HANDSHAKE LOGIC

When the Digital I/O board is used to read parallel words in either a bcd or binary format, the user may select one of three different handshake schemes through which the data may be entered. In addition, the user may select either noninverted or inverted polarity for each of the handshakes and may choose between a single or continuous update mode.

In the continuous update mode, data may be continuously loaded between transfers to the mainframe controller, thereby ensuring that only the most recent data is measured. In the single update mode, the data may be loaded only once between transfers; any further loads are inhibited until the data has been retrieved by the mainframe controller.

PARALLEL INPUT AND OUTPUT INTERFACE

This circuit block consists of data storage latches, tri-state buffers to read from and write to the latches, and input and output buffers. The latches are used to store the data output when the Digital I/O is used for status output, and they are used to store the parallel bcd or binary input data when used as a digital input.

Detailed Circuit Description

POWER SUPPLY

Dc-Dc Converter

Isolation of the Digital I/O circuitry is provided by T1 which is also the core of the dc-dc converter. In the dc-dc converter, T1, U1, Q1, and Q2 comprise a "flyback" type of switching regulator converter. Incoming dc power from 10V dc to 25V dc is applied to the primary of T1 for an interval generated by U1, causing the primary current to ramp up to approximately 1 ampere peak before Q1 and Q2 are turned off. The energy stored in T1 is then released through CR10 and CR12, into C5 and C20 respectively. The voltage on C5 is sampled by R9, R10, and R11, and a feedback error signal is generated and relayed to U1. The duty cycle of Q1 and Q2 is then adjusted by U1 to maintain C5 at 5.0V despite load changes.

The voltage on C20 is used to supply all isolated circuitry on the assembly. The voltage on C5 is used to power the serial link interface circuits.

Adjustment potentiometer R11 is used to set the isolated 5V dc supply voltage (GL +5) to 5V. This can be measured between test points TP2 and TP20.

Reset Generator

When power is first applied to the Digital I/O, Q6 is turned on by R36, and the power-on reset signal (POR(L)) to the controller is held low. U24 compares the voltage on C22 to a 1.22V reference provided through VR3 to determine whether the +5V supply is within tolerance. Once the supply voltage has stabilized, C21 is allowed to charge through R28 and R33, generating a delay of approximately 50 ms before C21 charges to 1.22V. This causes U24 to remove the drive to Q6, allowing POR(L) to be pulled high by R37.

SERIAL LINK

There are three major components in the serial link interface: a Universal Asynchronous Receiver/Transmitter (U8), a bidirectional optical interface (U4 and U5), and a differential driver (U2) and receiver (U3).

To improve the operation of the system in an electrically noisy environment, differential line drivers in U2 and receivers in U3 transmit and receive information through transient suppression networks consisting of resistors R12, R13, R14, R15, R18, R19, R20, and R21 and diodes CR1 through CR8 in conjunction with VR2.

When data is transmitted from the Digital I/O Assembly to the system controller, the processor places the eight-bit word on the Digital I/O Assembly internal data bus accompanied by a WRITE STROBE. The UART accepts each of the parallel eight-bit words from the processor and converts them to a serial data stream. The serialized data is then sent through the optical coupler (U4, pins 3, 4, 5, and 6) and driver (U2) onto the serial link. Because there may be a number of different devices on the link, the drivers are placed in a high-impedance state when they are not actively involved in transferring data. Driver tri-stating is accomplished by the signal from microcomputer port 1, bit 5, which is transferred through an optical coupler (U4, pins 1, 2, 5, and 7).

Incoming data from the Front End mainframe controller assembly is fed into the UART (U8) through optical coupler U5. Upon receipt of a data byte, the UART interrupts the microcomputer (U7).

The clock for the UART is provided by the Address Latch Enable (ALE(H)) signal from the microprocessor. Clock frequency is 16 times the 25,000 baud bit rate of the serial link.

ADDRESS SELECT

Two thumbwheel switches, S1 and S2, on the Digital I/O Assembly are used to select the address range for that assembly. The microcomputer reads the current switch settings through buffers in U27 and U28 when they are enabled by setting port 1 bit 6 low.

Each time a command is received from the mainframe controller, the state of the address switches is checked. If the address within the command falls within the address block selected through the switches, the remainder of the message is decoded and executed. If the address does not match, the command from the mainframe controller is ignored.

MICROCOMPUTER

The microcomputer on the Digital I/O Assembly (U7) has 1024 bytes of internal EPROM memory and 64 bytes of internal RAM. There is no external memory on the Digital I/O Assembly. A 6-MHz crystal (Y1) provides the frequency reference for the clock generated within the microcomputer. The microcomputer, in turn, generates the 400K Address Latch Enable (ALE(H)) signal used as the clock for the remainder of the subsystem.

The microcomputer has two 4-bit input/output ports, which are used to develop a number of control signals throughout the Digital I/O board. In addition, there is an 8-bit data bus used for data transfer within the Digital I/O Assembly.

HANDSHAKE LOGIC

Five subcircuits comprise the handshake logic: the three handshake circuits, the single/continuous control circuit, and the load control circuit. Handshake logic provides three alternate means by which data may be entered. In response to an external load signal, the selected handshake circuit generates the appropriate acknowledge and a store signal to the load control circuit.

The three independent handshake circuits are discussed in the following paragraphs. All signals in the accompanying illustrations are shown in the noninverted polarity.

Handshake Type One Circuit

Counter U34, flip-flops U20 (labeled F and G), and gates U12, U13, U15, U16, and U18 comprise the type one handshake circuit. Refer to Figure 168-3. Immediately following power on, the circuit is in its initial state with both flip-flops reset. One clock pulse after the counter output (P) transitions to a logical one, flip-flop G sets, generating the leading edge of the ACK1 output pulse. Approximately 32 microseconds later, P returns to the logical zero state, then flop-flop F is set and the trailing edge of ACK1 is generated.

After the ACK1 output pulse is generated, the circuit is ready to accept the LOAD 1 input pulse from the user's circuitry. When LOAD 1 transitions to a logic 0, the G flip-flop resets and the leading edge of the STORE command is sent to the Load Control circuit. The incoming data is stored. When the LOAD 1 command returns to the logic 1 state, flip-flop F resets and the sequence is complete.

```
ACK 1 (output)  __/‾‾‾‾‾\__    _____     _/‾‾‾‾‾_____

LOAD 1 (input)  _____  __        __  _____
                                _____/

Data (input)    _____   _ _____ __  _____
                _____   _X_____X_  _____
```
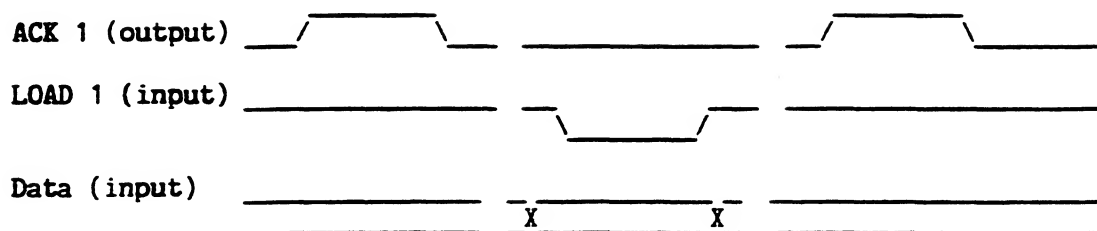
Figure 168-3. Handshake Type One Timing Diagram

Handshake Type Two Circuit

Flip-flops U21 (labeled D and E) and gates U12, U13, and U16 implement the circuit for the type two handshake. Refer to Figure 168-4. Immediately following power up, flip-flops D and E are in the reset state, from which flip-flop E transitions to the logic 1 state to generate the leading edge of the ACK 2 output signal. The external device may now generate the leading edge of the LOAD 2 input signal. In response to the LOAD 2 zero-to-one transition, the external data is stored and flip-flop E is reset, thus, generating the trailing edge of the ACK 2 signal. When LOAD 2 returns to the logic 0 state, ending the handshake, flip-flop D is reset.

```
ACK 2 (output)  _____/‾‾‾ ‾‾‾\__   _____

LOAD 2 (input)  _____  _/‾‾‾ ‾‾‾_____

DATA (input)    _____ _____ _____ _____ ____
                _____X_____ _____ _____X____
```
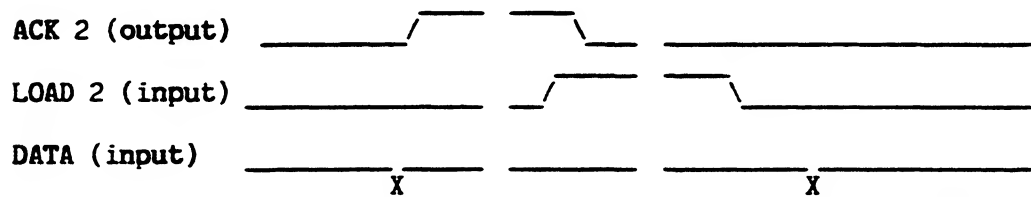
Figure 168-4. Handshake Type Two Timing Diagram

Handshake Type Three Circuit

The final handshake circuit consists of gates U12 and U15. Data may be loaded into the data storage register using this method any time that the BUSY output is in the logic zero state. The LOAD 3 input command is accepted by the Digital I/O Assembly and is passed on immediately to the Load Control circuit. Refer to Figure 168-5.

```
LOAD 3 (input)  ___  ___ ____ ___ ____ ___ _____  __
                   \_/    \_/   \_/                   \_/

BUSY (output)   _____/‾‾‾‾‾_____

DATA (input)    ____ _ _ ____ _ _ ____ _ _ _____ _ _ __
                ____ X X ____ X X ____ X X _____ X X __
                     VALID      VALID      VALID        VALID
```
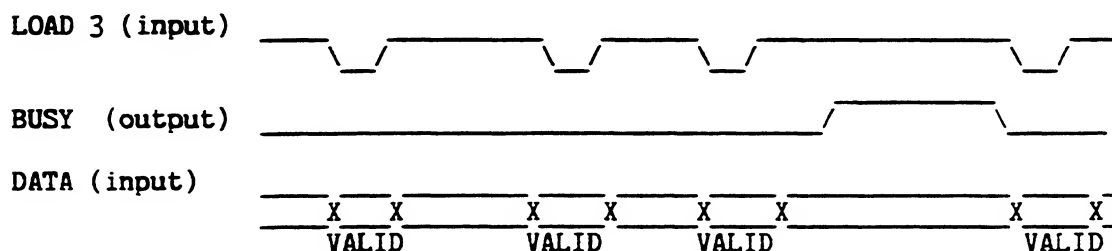
Figure 168-5. Handshake Three Timing Diagram

Load Control Logic

The load control circuit accepts the STORE signal from any of the three handshake circuits and develops a LOAD pulse to the data storage register to strobe in the external data. The load control circuit also prevents loading during a read cycle.

Three flip-flops within U22, and gates U16 and U17 comprise the load control logic. The load control logic is a sequential circuit that accepts a STORE signal from the handshake circuits and a READ signal from the microcomputer and generates a LOAD signal to the data storage register.

Upon initialization, flip-flops A, B, and C are in the reset state. One clock pulse later, C becomes set and arms gate U16 in anticipation of a STORE command. When the STORE command occurs, flip-flops A and B are set, and they remain set until the command is terminated. The Q outputs of flip-flops A and B are ANDed through U17 which, in turn, forms the D input to flip-flop C and generates the leading edge of the load strobe to the data storage register. Flip-flop C, with its D input at a logic zero, is reset on the clock pulse and therefore generates the trailing edge of the load strobe.

When the LOAD command terminates, the sequential machine returns to the quiescent state where it waits for the next command. When the READ signal is received, flip-flops A and B are prevented from changing state; therefore, a load strobe cannot be generated.

Single/Continuous Control Circuit

The single/continuous control circuit determines whether data is loaded continuously or only once between reads by the system controller. The single/continuous logic consists of flip-flop U25 and several gates in U14 and U23. If the board is in the continuous mode, the flip-flop is held in the reset state and does not affect the board operation.

If, however, the single mode has been selected, the flip-flop is set upon receipt of the first load command from an external device. When the flip-flop is set, the signal HANDSHAKE ENABLE becomes false, and the three handshake circuits are held in the reset state until the latched data is read. Following the read, the flip-flop is reset and the process may repeat.

PARALLEL INPUT AND OUTPUT INTERFACE

A temporary data storage register comprised of three 8-bit latches (U6, U29, and U40) is the focal point for all parallel data transfer between the Digital I/O Assembly and external devices. Since parallel data transfer operations are different for each of the operating modes (status input, status output, and digital input), the interface circuit will be discussed in terms of the operating mode selected.

Because the Digital I/O Assembly may be user-configured to perform three
different functions, the microcomputer must determine which function has
been selected.

Upon power-up, or when the system controller requests configuration,
microcomputer port 2, bit 6, goes to logic 0 which gates the three most
significant bits of the parallel input word onto the internal data bus.
A READ strobe is then issued to accept the data, and port 2, bit 6,
returns to the logic 1 state.

If the Digital I/O Assembly is used for status input (with a -179
Digital/Status Input connector), it must fetch the user input data when
commanded. The first step is to gate the external data, buffered through
U41, U42, U43, and U44, to the inputs of the set of latches, U6, U29,
and U40. Gating is accomplished by placing port 2, bit 6, in the logic 0
state to place the input data on the inputs of the three latches. Next,
port 2, bit 7, is pulsed from high to low and back to high to strobe the
data into the latches. Port 2, bits 0 through 2, are then sequentially
placed in the logic 0 state and returned to the logic 1 state. At the
same time, a READ strobe is issued and the data is brought into the
processor through buffers U36, U37, U38, and U39.

If the Digital I/O Assembly is used for status output (with a -179
Status Output Connector), operation is directly analogous to the status
input configuration. In the status output configuration, port 2, bits 6
and 7, are placed in the logic 1 state and port 2, bits 0 through 2, are
sequentially placed in the logic 0 state, then returned to the logic 1
state. While each port bit is in the logic 0 state, a WRITE strobe is
issued to clock the output data from the processor into the appropriate
latch through buffers U30, U31, U32, and U33.

The digital input configuration operates exactly like the status input
configuration except that there is no need to store the data in the
on-board latches since it has already been stored there through the
action of the handshake sequence.

Outputs from the Digital I/O assembly are buffered to the external
circuitry though buffers U46, U47, and U48. Data inputs to the assembly
are buffered through U41, U42, U43, and U44.

GENERAL MAINTENANCE

The Digital I/O Assembly normally requires no cleaning unless dirt,
dust, or other contamination is visible on its surface.

If cleaning is necessary, follow the cleaning instructions in Section 4
of this manual.

PERFORMANCE TESTS

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES
THAT ARE DANGEROUS AND CAN BE FATAL. ONLY
QUALIFIED PRESONNEL SHOULD ATTEMPT TO SERVICE THIS
EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL
POWER SOURCES BEFORE PERFORMING THE FOLLOWING
PROCEDURES.

Two performance tests are necessary to verify the Digital I/O Assembly's
output and input capability, one for each of the two possible input
connectors that may be used with the Assembly. Although both tests (with
both connectors) are necessary to fully test the Digital I/O Assembly
under all conditions, either test may be performed independently for a
partial performance evaluation.

To perform these tests, it is necessary to gain access to the terminals
of the connector being used. There are two ways of doing this:

Alternative 1.

Install a Calibration/Extender Fixture (Fluke P/N 648741) in one of
the Front End option slots and install the Digital I/O Assembly and
the connector on the fixture. Be sure the switch on the fixture is
set to the EXTEND position.

Using this method, the connector's terminals are accessible at all
times.

Alternative 2.

If a Calibration/Extender Fixture is not available, remove all
other options from the Front End and install the Digital I/O
Assembly in the bottom slot. Remove the connector's cover and
install the connector on the Digital I/O Assembly.

In this configuration, the terminals can be reached without using
an extender.

Output Test

The Output Test verifies operation of the Digital I/O Assembly's output
capability. This test requires use of the -169 Status Output Connector.

To conduct the Output Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power
    cord and all other high voltage inputs.

2. Install a Calibration/Extender Fixture in the uppermost option slot
    of the Front End. Set the fixture switch to the EXTEND position.

3. Set the Digital I/O channel decade switches to 00, then install the
    Digital I/O Assembly on the Calibration/Extender Fixture.

4. Install the -169 Status Output Connector on the Digital I/O Assembly.

5. Reconnect the ac line cord to the Front End and switch the power
    ON.

6. Testing the output drive capability of each channel requires an
    external voltage source, a current limiting/pull-up resistor, and a
    DMM, interconnected as shown in Figure 168-6 and described below:
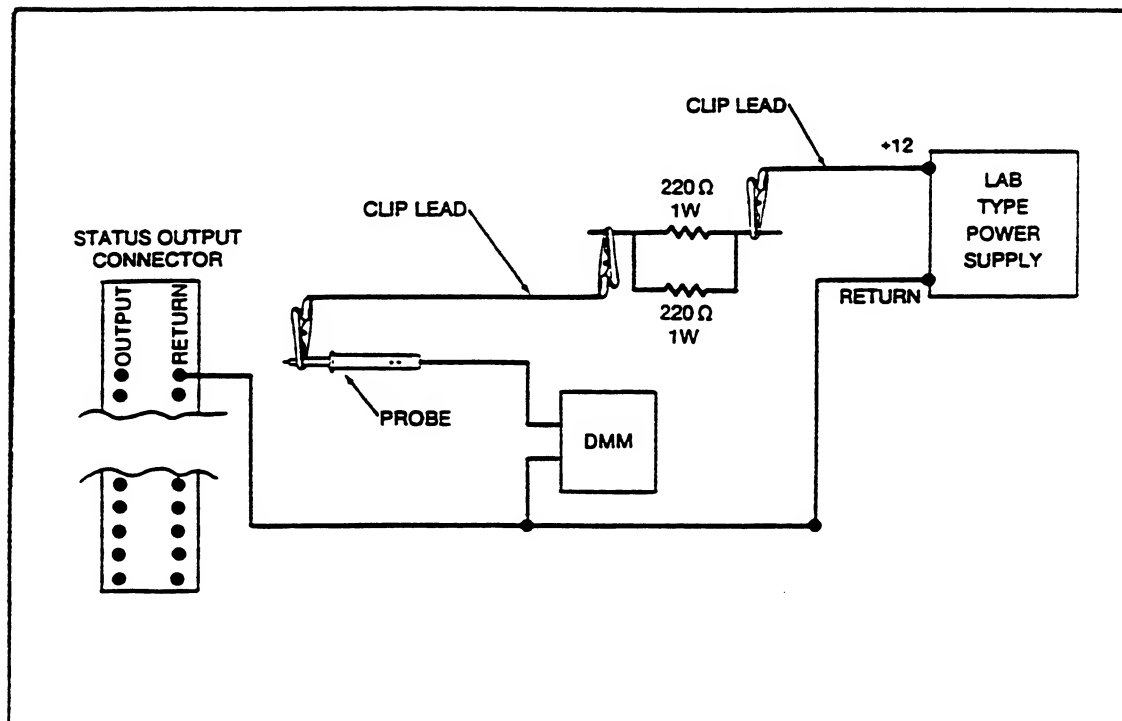
Figure 168-6. Interconnecting Output Test Equipment

A. Using clip leads, connect a +12V lab type power supply to one
    side of two 220 ohm, 1W carbon resistors wired in parallel.

B. Connect the power supply RETURN (-) terminal to the RETURN
    terminal of the -169 Status Output Connector.

C. Using clip leads, connect the other side of the resistor to the
    probe of the DMM's volt/ohm input (red) test lead.

D. Connect the DMM's common lead (black) to RETURN on the Status
    Output connector.

E. Set the DMM to measure a full scale voltage of +12V, turn the
    power supply ON, and ensure that the DMM reads approximately
    12V.

Figure 9A-14. A1 Scan/Alarm Computer Interface PCA

2289A-1005
(1 of 3)

Figure 9A-14. A1 Scan/Alarm Computer
Interface PCA (cont)

2289A-1005
(2 of 3)

Figure 9A-14. A1 Scan/Alarm Computer
Interface PCA (cont)
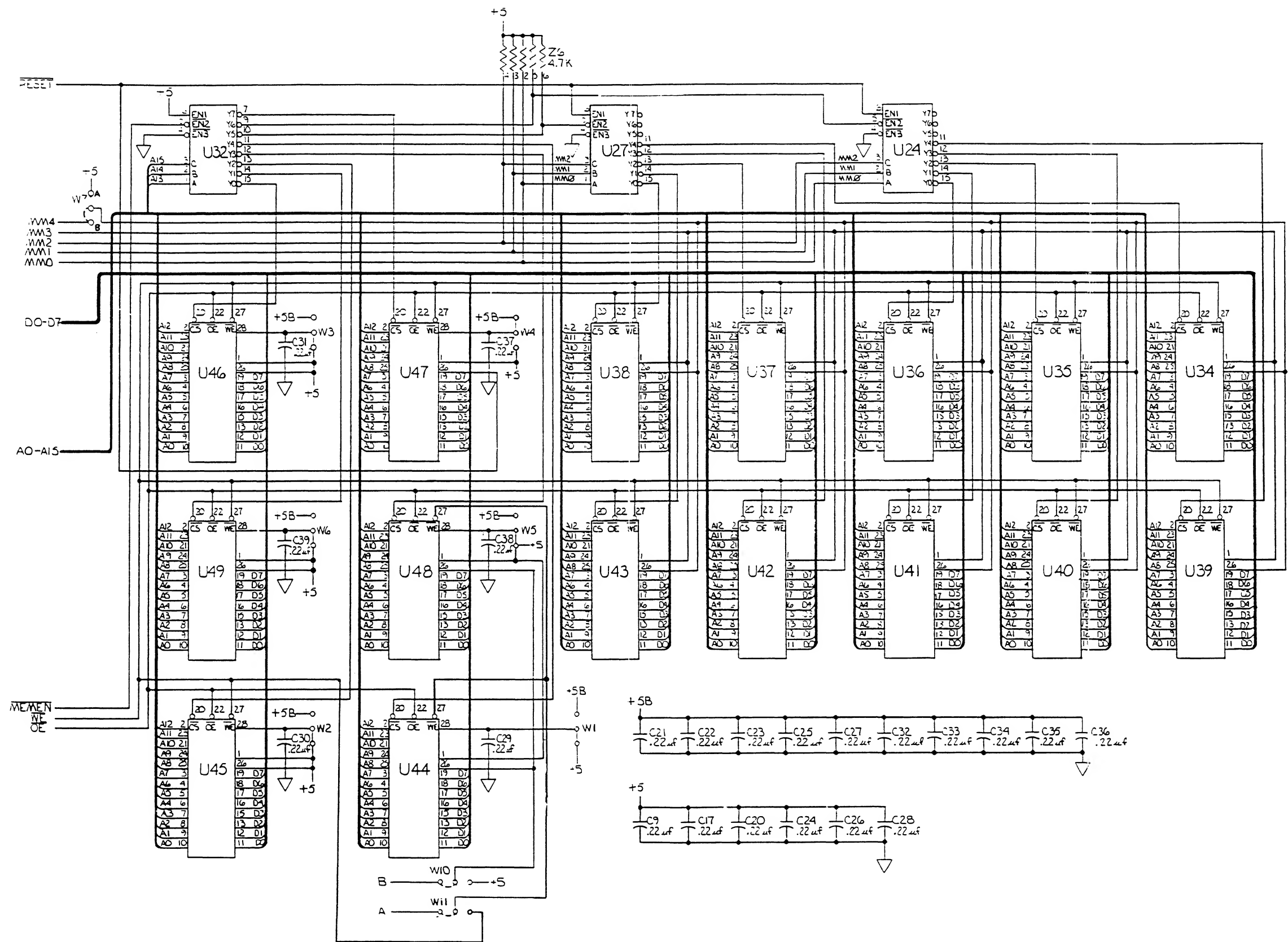
2289A-1005
(3 of 3)
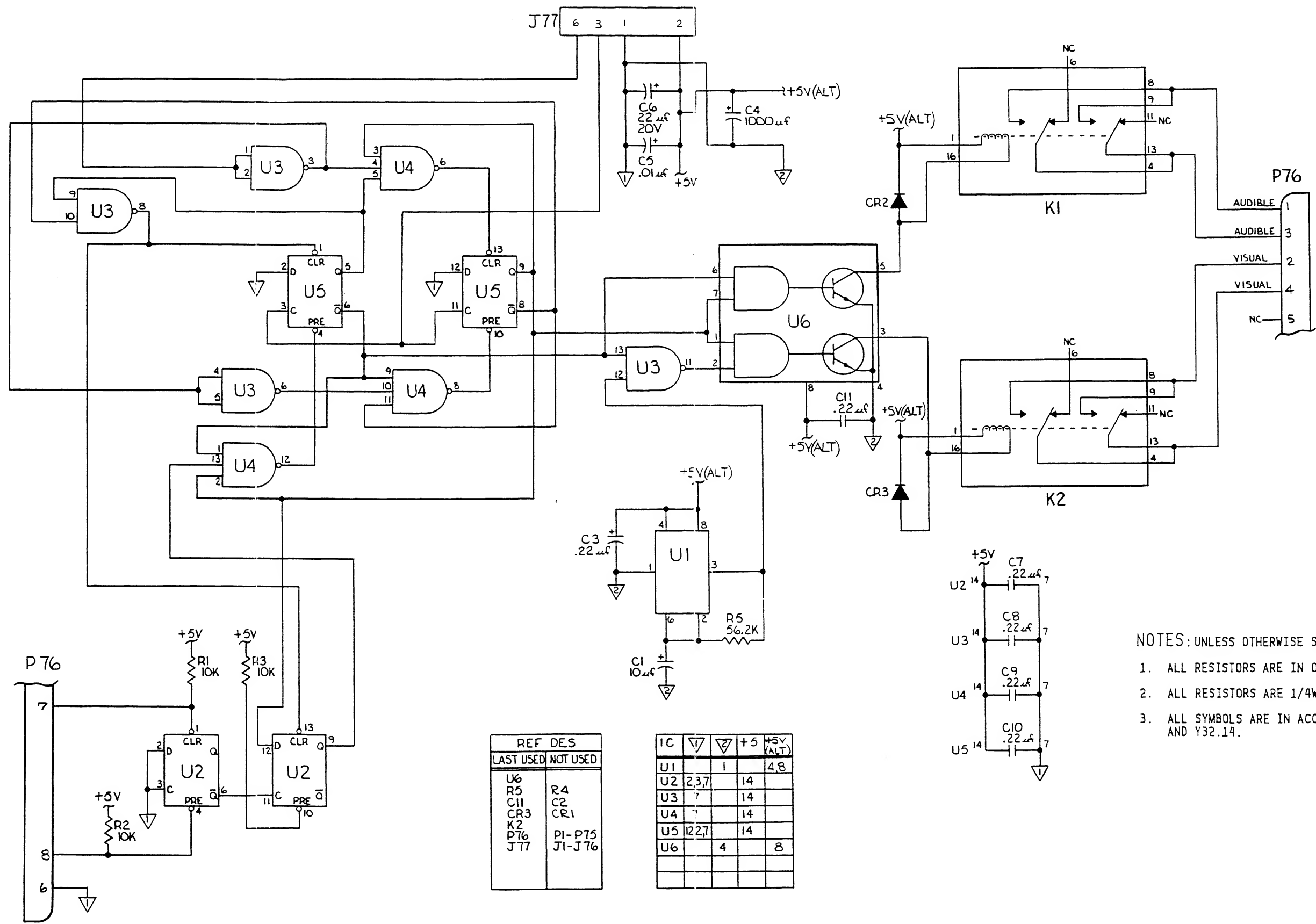
Figure 9A-15. A2 Alarm Annunciator PCA

2289A-1004

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..19)=STATOUT <CR>

CHAN(0..19)=0 <CR>
```

A1. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector.

   The DMM should continue to read +12V, indicating that the status output for channel 0 HAS NOT been turned ON.

A2. Repeat step A1 for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

A3. Send the following commands to the Front End:

```
CHAN(0..19)=1 <CR>
```

A4. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector.

   The DMM should read 1V or less, indicating that the status output for that channel HAS been turned ON, and that it is able to sink a minimum of 100 mA.

A5. Repeat step A4 for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs will cause the Front End to perform the required tests on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for an IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 200
90  PRINT #1,"def chan(0..19)=statout"
100 GOSUB 200
120 PRINT #1,"chan(0..19)=0"
130 GOSUB 200
140 END
200 REM wait for message accepted prompt
210 INPUT #1,A$
220 IF A$<>"!" THEN GOTO 210
230 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:" AS NEW FILE 1%
50  OPEN "KB1:" AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Computer Front End
80  PRINT #1,"mode=comp"
90  GOSUB 200
100 PRINT #1,"def chan(0..19)=statout"
110 GOSUB 200
120 PRINT #1,"chan(0..19)=0"
130 GOSUB 200
140 END
200 REM wait for message accepted prompt
210 INPUT #2,A$
220 IF A$<>"!" THEN GOTO 210
230 RETURN
```

B1. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector.

The DMM should continue to read +12V, indicating that the status output for channel 0 HAS NOT been turned ON.

B2. Repeat step B1 for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

B3. Change line 120 in the above program to:

   PRINT #1,"chan(0..19)=1"

   Run the modified program.

B4. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector.

   The DMM should read 1V or less, indicating that the status output for that channel HAS been turned ON, and that it is able to sink a minimum of 100 mA.

B5. Repeat step B4 for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

7. This completes the Output Test for the Digital I/O Assembly.

Input Test

The Input Test verifies operation of the Digital I/O Assembly's input capability. This test requires use of the -179 Digital/Status Input Connector.

To conduct the Input Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install a Calibration/Extender Fixture in the uppermost option slot of the Front End. Set the fixture switch to the EXTEND position.

3. Set the Digital I/O channel decade switches to 00, then install the Digital I/O Assembly on the Calibration/Extender Fixture.

4. Using a small jumper wire, short SIGNAL to RETURN on terminal 21 of the Digital/Status Input Connector.

   Remove all other connections. Install the input connector on the Digital I/O Assembly.

5. Reconnect ac line power to the Front End and switch the power ON.

6. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..19)=STATIN <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0..19) <CR>
```

A1. Verify status input responses.

Because all status channel inputs (0..19) are open, the measurement should be returned as a 1 (1.00000E+00).

A2. Short the SIGNAL to RETURN terminals for channel inputs 0 through 19.

A3. To take new readings, send the Front End the following command:

```
SEND CHAN(0..19) <CR>
```

A4. The returned readings for all 20 channels should be 0 (0.00000E+00).

PROCEDURE B. COMPUTER MODE:

The following sample BASIC programs will cause the Front End to take a status reading on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for an IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port and empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
```

```
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0..19)=statin"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT #1,"send chan(0..19)"
180  FOR I=0 TO 19
190  INPUT #1,M$
200  PRINT "chan";I;"=";
210  PRINT M$
220  NEXT I
230  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:" AS NEW FILE 1%
50   OPEN "KB1:" AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..19)=statin"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  DIM M$(20)
180  PRINT #1,"send chan(0..19)"
190  FOR I%=0 TO 19\INPUT #2,M$(I%)\NEXT I%
200  X%=0\I%=0
210  FOR C%=0 TO 1
220  PRINT TAB (35*C%);"chan";I%;"=";
230  PRINT M$(X%);
240  X%=X%+1\I%=I%+1\IF X%>19 THEN 270
250  NEXT C%
260  GOTO 210
270  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

B1. Verify status input response.

Because all status channel inputs (0..19) are open, the measurement should be returned as 1 (1.00000E+00).

B2. Short the SIGNAL to RETURN terminals for channel inputs 0 through 19.

B3. Run the program again to take new readings.

B4. The returned readings for all 20 channels should be 0 (0.00000E+00).

7. This completes the Digital I/O Assembly Input Test.

CALIBRATION

The Digital I/O Assembly requires no calibration.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Digital I/O Assembly is given in Table 168-4.

For parts ordering information, refer to Section 6 of this manual.

Figure 168-7 is a schematic diagram of the Digital I/O Assembly.

TABLE 168-4. -168 DIGITAL I/O PCA
(SEE FIGURE 168-7.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 1		CAP,AL,330UF,+100-10%,25V	614404	89536	614404	1		
C 2, 3		CAP,CER,1000PF,+-10%,500V,X5S	357806	56289	C016B102G102K	2		
C 4		CAP,POLYES,0.22UF,+-10%,100V	436113	73445	C280MAH1A220K	1		
C 5		CAP,AL,270UF,+100-10%,20V	602656	89536	602656	1		
C 8- 19, 22-		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RFE111Z5U224M50V	25		
C 20		CAP,AL,470UF,+100-10%,12V	602649	89536	602649	1		
C 21		CAP,TA,0.47UF,+-20%,35V	161349	56349	196D474X0035HA1	1		
C 32		CAP,TA,10UF,+-20%,20V	330662	562B9	196D106X0020KA1	1		
C 36		CAP,CER,0.01UF,+-20%,100V,X7R	407361	72982	8121-A100-W5R-103M	1		
CR 1- 8	●	DIODE,SI, 50 PIV, 1.0 AMP	379412	04713	1N4933	8		
CR 9, 11, 13	●	DIODE,SI,BV= 75.0V,ID=150MA,500 MW	203323	07910	1N4448	3	2	
CR 10, 12	●	DIODE,SI, 20 PIV, 1.0 AMP	507731	83003	VSK120	2	1	
E 1, 2, 20,		TERM,FASTON,TAB,SOLDR,0.110 WIDE	512889	02660	62395	12	1	
E 23, 24, 30-			512889					
E 32, 50, 58,			512889					
E 82, 83			512889					
F 1		FUSE,PICO,FAST,0.5A,125V	603274	71400	GFA	1	1	
H 1		NUT,MACH,HEX,STL,4-40	110635	89536	110635	4		
H 2		WASHER,LOCK,SPLIT,STEEL,#4	110395	89536	110395	4		
H 4		NYLON, STEM:OD=.093",L=.115	195909	89536	195909	1		
H 5		INSERT,STUD,BROACHING,PHOSPHOR BRONZE	494682	89536	494682	2		
H 6		INSERT,STUD,BROACHING,PHOSPHOR BRONZE	614636	89536	614636	2		
L 2		CHOKE 550UH	645721	89536	645721	1		
MP 1		RETAINER,P.C.B.	579078	89536	579078	2		
MP 2		SPACER,RND,ALUM,0.156IDX0.250	153155	89536	153155	2		
MP 3		BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1		
MP 4		SPACER,MOUNT,NYLON.	175125	89536	175125	1		
MP 31, 33- 35			175125					
Q 1	●	SILICON, NPN, FAST SWITCHING D44H11	535542	89536	535542	1	1	
Q 2	●	TRANSISTOR,SI,NPN,HI-VOLTAGE	370684	04713	MPS A 42	1	1	
Q 3- 5	●	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	04713	2N3906	3	1	
Q 6	●	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	1	1	
R 1		RES,CF,1.8K,+-5%,0.25W	441444	80031	CR251-4-5P1K8	1		
R 2		RES,CF,1.5K,+-5%,0.25W	343418	80031	CR251-4-5P1K5	1		
R 3		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	1		
R 4		RES,CF,510,+-5%,0.25W	441600	80031	CR251-4-5P510E	1		
R 5, 6, 9,		RES,MF,4.99K,+-1%,0.125W,100PPM	168252	91637	MFF1-84991	4		
R 10			168252					
R 7		RES,MF,16.9K,+-1%,0.125W,100PPM	267146	91637	CMF551692F	1		
R 8, 24- 26		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	4		
R 11		RES,VAR,CERM,1K,+-10%,0.5W	275750	11236	360T-102A	1		
R 12, 13, 18,		RES,CF,51,+-5%,0.25W	414540	80031	CK251-4-5P51E	4		

TABLE 168-4. -168 DIGITAL I/O PCA
(SEE FIGURE 168-6.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	---------DESCRIPTION---------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
R 19			414540					
R 14, 15, 22,		RES,CF,270,+-5%,0.25W	348789	80031	CR251-4-5P270E	5		
R 38, 39			348789					
R 16, 17, 23,		RES,CF,5.6K,+-5%,0.25W	442350	80031	CR251-4-5P5K6	4		
R 27			442350					
R 20, 21		RES,CF,30,+-5%,0.25W	442228	80031	CR251-4-5P30E	2		
R 28		RES,MF,154K,+-1%,0.125W,100PPM	289447	91637	CMF551543F	1		
R 29, 35		RES,CF,1M,+-5%,0.25W	348987	80031	CR251-4-5P1M	2		
R 30, 34, 36		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	3		
R 31		RES,MF,26.7K,+-1%,0.125W,100PPM	245779	91637	CMF552672F	1		
R 32		RES,CF,2K,+-5%,0.25W	441469	80031	CR251-4-5P2K	1		
R 33		RES,MF,332K,+-1%,0.125W,100PPM	289504	91637	CMF553323F	1		
R 37		RES,CF,20K,+-5%,0.25W	441477	80031	CR251-4-5P20K	1		
R 40- 42		RES,CF,82,+-5%,0.25W	442277	80031	CR251-4-5P82E	3		
S 1		SWITCH,ROTARY,1 POLE,16 POS,1 THUMB	615096	97527	1A-21-60-33-G-F	1		
S 2		SWITCH,ROTARY,1 POLE,10 POS,1 THUMB	602888	97527	1A-21-60-02-G-F	1		
T 1		INVERTER TRANSFORMER	617803	89536	617803	1		
U 1	*	IC,REGULATING PULSE WIDTH MODULATOR	454678	01295	SG3524N	1	1	
U 2	*	IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	12040	DS1692J	1	1	
U 3	*	IC,BPLR,DIFFERENTIAL LINE RECEIVER	586073	01295	SN55182J	1	1	
U 4	*	ISOLATOR,OPTO,HI-SPEED,DUAL	429894	28480	5082-4355	1	1	
U 5	*	ISOLATOR,OPTO,HI-SPEED,8 PIN DIP	354746	89536	354746	1	1	
U 6, 29, 40	*	IC,CMOS,DUAL 4BIT LTCH W/STROBE&RESET	605261	04713	MC14508BCP	3	1	
U 7		IC,NMOS,8 BIT MICROCOMPTR,1KX8 EPROM	454652	89536	454652	1		
U 8	*	IC,CMOS,UNIV ASYNC RECEIVR/TRANSMITER	453464	32293	IM6402CPL	1	1	
U 9	*	IC,LSTTL,QUAD 2 INPUT NOR GATE	642884	01295	SN54LS02J	1		
U 10	*	IC,LSTTL,QUAD 2 INPUT OR GATE	605618	01295	SN54LS32J	1	1	
U 11	*	IC,LSTTL,QUAD 2 INPUT NAND GATE	605600	01295	SN54LS00J	1	1	
U 12, 19	*	IC,CMOS,HEX INVERTER	404681	02735	CD4069BE	2	1	
U 13	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1	1	
U 14, 26	*	IC,CMOS,QUAD 2 INPUT OR GATE	408393	02735	CD4071BE	2	1	
U 15, 16	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001AE	2	1	
U 17	*	IC,CMOS,QUAD 2 INPUT NAND GATE	453241	02735	CD4011BE	1	1	
U 18, 23	*	IC,CMOS,TRIPLE 3 INPUT NOR GATE	355180	02735	CD4025AE	2	1	
U 20, 21, 25	*	IC,CMOS,DUAL JK F/F,+EDG TRIG	355230	02735	CD4027AE	3	1	
U 22	*	IC,CMOS,QUAD D F/F,+EDG TRG	536292	04713	MC14175B	1	1	
U 24	*	IC,COMPARATOR,DUAL,LO-PWR,8 PIN DIP	478354	12040	LM393N	1	1	
U 27, 28, 30-	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	14	1	
U 33, 36- 39,	*		407759					
U 41- 44	*		407759					
U 34	*	IC,CMOS,7STAGE RIPPLE CARRY BIN CNTR	412965	86684	CD4024AE	1	3	
U 35, 45	*	IC,CMOS,QUAD XOR GATE	355222	02735	CD4030AE	2	1	
U 46- 48	*	IC,ARRAY,7 TRANS,NPN,DARLINGTON PAIRS	454116	01295	ULN2003	3	1	
VR 1	*	ZENER,UNCOMP, 24.0V, 5%, 5.2MA, 0.4W	267807	04713	1N970B	1	1	
VR 2	*	ZENER,UNCOMP,6V TRANSIENT SUPPRESSOR	508655	24444	1N5908	1	1	
VR 3	*	IC, 1.22V,100 PPM T.C.,BANDGAP REF	452771	89536	452771	1	1	
XU 7, 8		SOCKET,IC,40 PIN	429282	89536	429282	2		
Y 1	*	CRYSTAL,6MHZ,+-0.01%,HC-18/U	461665	89536	461665	1	5	
Z 1- 3		RES,NET,SIP,8 PIN,7 RES,10K,+-2%	412924	80031	95081002CL	3		
Z 4, 5		RES,NET,SIP,10 PIN,9 RES,10K,+-2%	414003	80031	95081002CL	2		
Z 7, 9, 11,		RES,NET,DIP,14 PIN,7 RES,100K,+-5%	516930	89536	516930	6		
Z 14, 16, 18			516930					
Z 8, 10, 12,		RES,NET,SIP,8 PIN,7 RES,47K,+-2%	413286	89536	413286	6		
Z 13, 15, 17			413286					

DESCRIPTION

The Status Output Connector (shown in Figure 169-1) connects 20 single-bit output signals from the Digital I/O Assembly (-168) to external points.

Each output channel is individually selectable by the Front End and can be used to drive lamps or relays, or to change logic levels.

The Status Output Connector plugs onto the 44-pin card-edge connector on the left side of the rear edge of the Digital I/O Assembly. The connector assembly is enclosed in a plastic housing that protects the terminals and provides strain relief for the external wiring. Retaining screws on each side of the housing fasten the connector assembly to the rear of the Computer Front End.
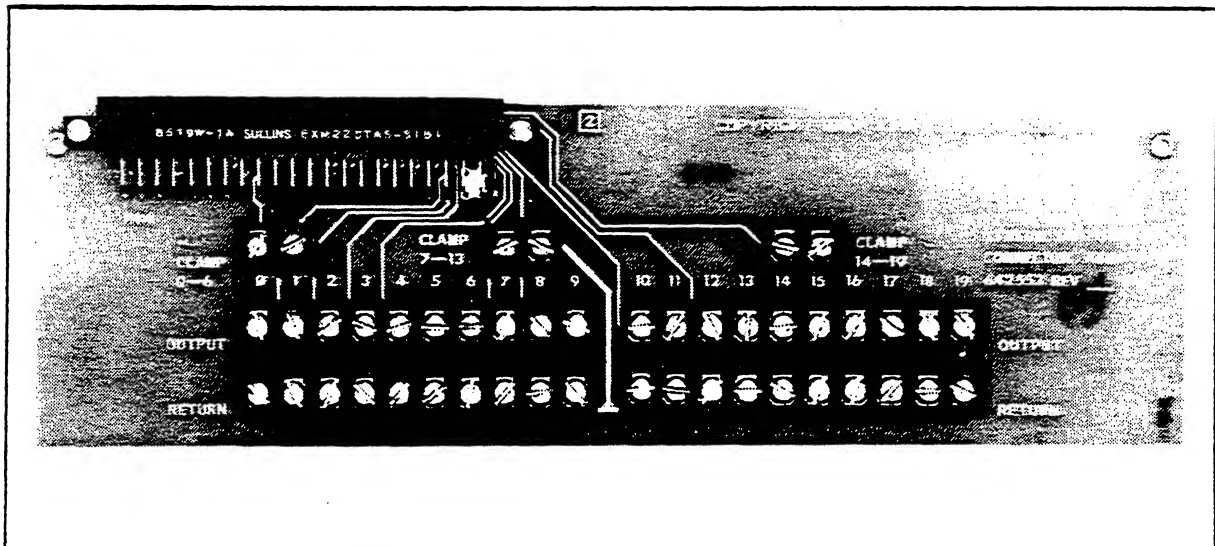
Figure 169-1. Status Output Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Status Output Connector theory of operation, performance test material, a replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are located in the Helios I System Manual.

THEORY OF OPERATION

The Status Output Connector theory of operation consists of a short functional description of the Status Output Connector. Refer to the schematic diagram at the end of this subsection for details of the circuit.

Overall Functional Description

The connector provides terminals for connecting wiring to equipment that is to be controlled by Front End status outputs. Output, return, and flyback diode clamp terminals are provided on the connector.

GENERAL MAINTENANCE

The -169 Status Output Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on the surface. If cleaning is necessary, follow the instructions in Section 4 of this manual.

PERFORMANCE TEST

There is no separate performance test for the -169 Status Output Connector.

The connector is tested during output mode performance test of the -168 Digital I/O Assembly performance test. Refer to the -168 Digital I/O Assembly subsection of Section 8.

CALIBRATION

The Status Output Connector does not require calibration adjustment.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Status Output Assembly is given in Table 169-1.

For parts ordering information, see Section 6 of this manual.

Figure 169-2 is a schematic diagram of the Status Output Assembly.

TABLE 169-1. -169 STATUS OUTPUT CONNECTOR
(SEE FIGURE 169-2.)

REFERENCE DESIGNATOR A->NUMERICS--->		S	---------DESCRIPTION---------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
H	1		STEEL,CAD.PLATED..125X .500	276493	89536	276493	2		
H	2		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	2		
MP	1		CONNECTOR HOUSING TOP	578971	89536	578971	1		
MP	2		CONNECTOR HOUSING BOTTOM	656876	89536	656876	1		
MP	3		DECAL, STATUS OUTPUT CONNECTOR	634568	89536	634568	1		
MP	4		DECAL, OPTION -169	634485	89536	634485	1		
MP	5		TAPE, FOAM, PVC, 1/4W 3/8 THK	603134	89536	603134	1		
P	44		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	1		
TB	1- 4		SINGLE ROW, .325 CENTERS, 10 POSITION	615328	89536	615328	4		
TB	5- 7		SINGLE ROW, .325 CENT., PCB MOUNT,	643858	89536	643858	3		
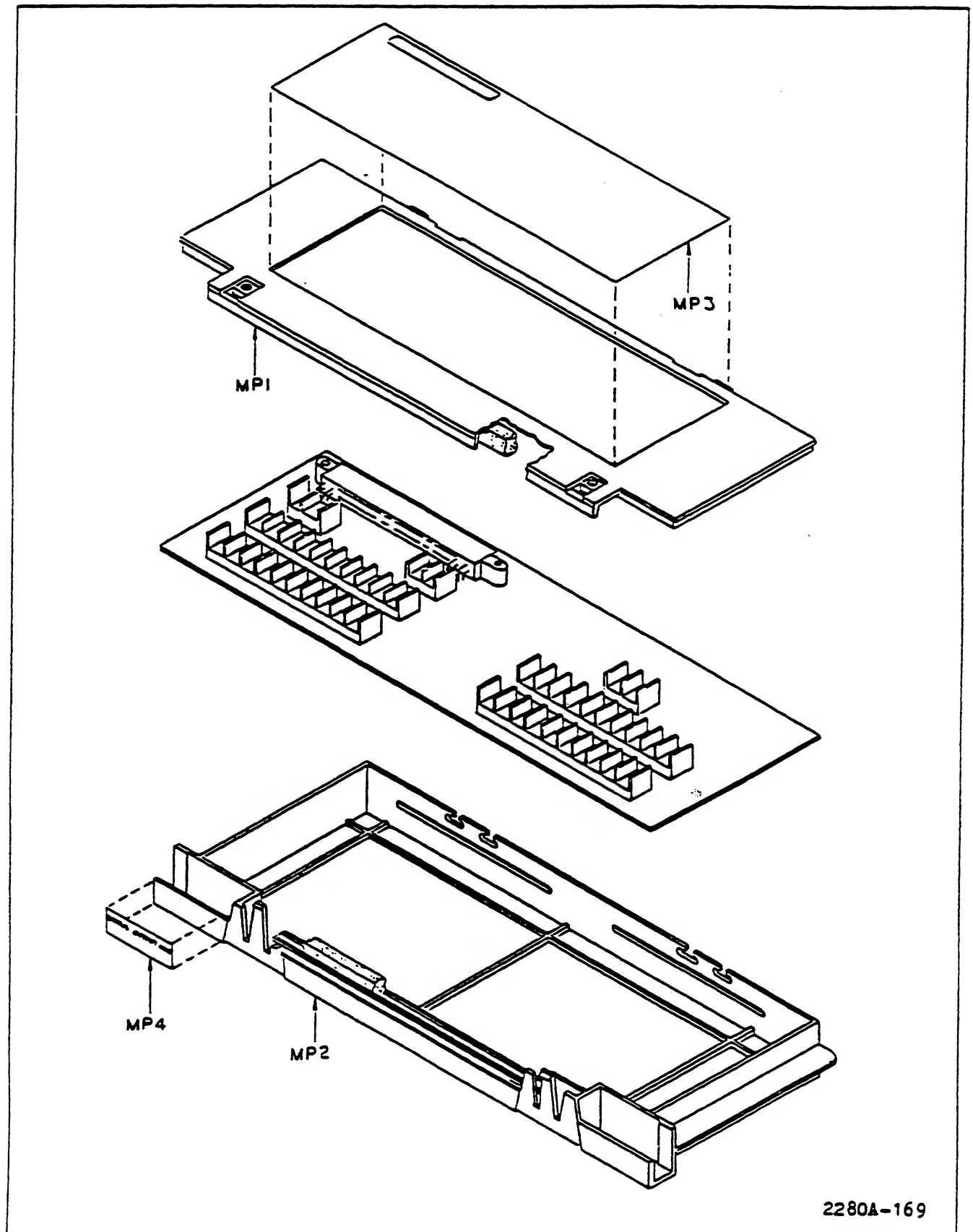
2280A-169

Figure 169-2. -169 Status Output Connector

CONTENTS

DESCRIPTION

Analog outputs are available from the mainframe through the -170 Analog
Output Assembly, shown in Figure 170-1.

The analog outputs provide voltage and current signals for applications
that require an analog input. There are four output channels on each
board. All four output channels are electrically isolated from chassis
ground, but not from each other. The four outputs share common returns
and voltage references. Each channel will supply 0 to +10V, -5 to +5V,
and 4 to 20 mA. Only one type of output is allowed per channel at a
given time.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Analog Output theory of operation, performance
tests, calibration procedures, a replacement parts list, and a schematic
diagram.

Installation, operating, and system configuration instructions are given
in the Helios I System Manual.

Test equipment required to perform the procedures in this subsection is
listed in Table 170-1. A summary of test equipment required to perform all
procedures in this manual is given in Table 2-2 in Section 2 of this
manual.

THEORY OF OPERATION

The Analog Output theory of operation includes a functional description,
a block diagram description, and a detailed circuit description. The
schematic diagram for this assembly is given at the end of this
subsection.

Functional Description

The analog output consists of four primary sections; a power supply, serial
link communication, digital control, and digital to analog conversion
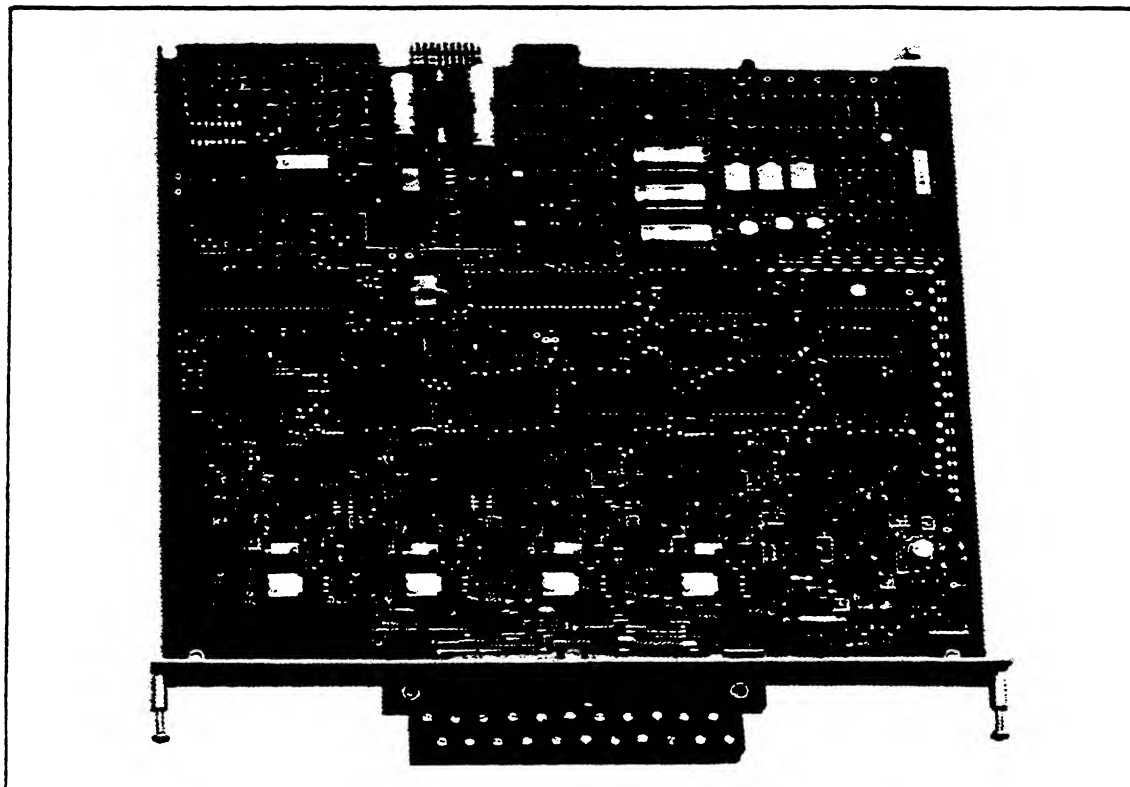
Figure 170-1. Analog Output

Table 170-1. Required Test Equipment for -170

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
Digital Multi-meter (DMM)	+/- 10V +/- 0.0001V	Fluke 8505A
Calibration/ Extender Fixture	NA	Fluke Accessory Part No. 648741 (no subsitute)

circuitry. Figure 170-2 is a block diagram showing the interrelationship between these sections. The communication circuitry is responsible for receiving and transmitting information to the mainframe via the serial link. The digital control circuitry directs the serial link communications and delivers a 12-bit data word received from the mainframe to the selected analog output circuitry. The analog circuitry converts this digital word to its corresponding voltage and current output.

Block Diagram Description

Communication circuitry includes: a serial link driver and receiver, three optical couplers, and a UART.
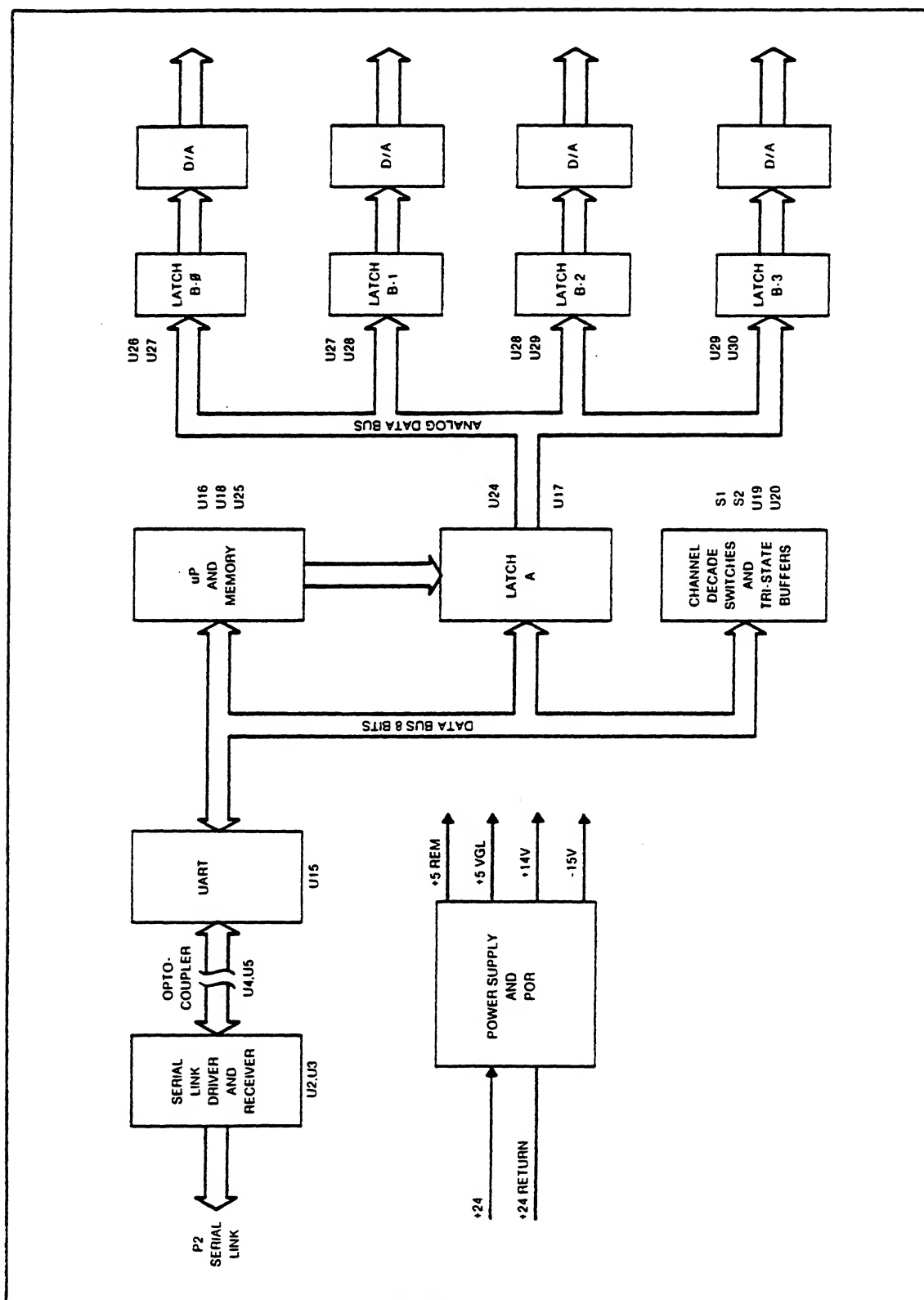
Figure 170-2. Analog Output Block Diagram

A receiver chip receives information from the serial link. The information is then transferred, using optical coupler isolation, to the UART in serial form. The UART converts the serial data to 8-bit data words to be read by the microprocessor. When a data word is ready, the UART interrupts the microprocessor. The microprocessor then reads the data supplied by the UART from the data bus, while checking for errors. To transmit data, the microprocessor loads information from the data bus into the UART and enables the transmit circuitry. When the transmit circuitry is enabled, the data is transferred, through an optical coupler, to the driver and onto the serial link.

Digital control circuitry consists of a microprocessor, decade switches with tri-state buffers, and latches to assemble and hold the 12-bit word for the digital-to-analog converters (DAC). The microprocessor directs the activities of the control circuitry. It oversees the UART communications with the mainframe controller assembly. Addresses received over the serial link are compared with the address selected through the decade switches to determine if the data is intended for this Analog Output assembly. The 12-bit data word for an output is loaded into intermediate latches and then passed to the latch associated with the intended output channel.

The digital-to-analog section consists of a 0 to +10V output, a 5V offset, and a voltage to current converter. The 5V offset, when used with the 0 to +10V output, provides a bipolar output of -5V to +5V. The voltage-to-current converter uses the 0 to +10V output to provide 4 to 20 mA.

Detailed Circuit Description

POWER SUPPLY

The power supply is a flyback converter. It will accept an input of 10 to 25V from the serial link. Voltages supplied by the converter are the 5V REM for remote serial link, 5VGL for the digital circuitry, and +14/-15V for the analog circuitry. The 5VGL, +14V, and -15V supplies have post linear regulators to provide additional regulation.

Inverter Section

A simplified schematic of the power supply is shown in Figure 170-3. Isolation is provided by T1. When the transistor, Q4, is turned on, the rectifying diodes are off, allowing the current in the primary of T1 to ramp up. Q4 is then turned off, causing the energy stored in T1 to be released into the secondaries through the diodes. The voltage on C15 is sampled by U10 and its supporting circuitry. If the voltage is above or below the nominal 5.4V, an error signal is generated. This error signal is relayed through the optical coupler to the control circuitry. The control circuitry varies the ratio of the time Q4 is on to the time Q4 is off to control the output voltage. The ratio of the on time to the off time is called the duty cycle. If the voltage sampled on C15 is lower than 5.4V, the control circuitry increases the duty cycle. If the sampled voltage is greater than 5.4V, the duty cycle is decreased. The voltages on C13, C14, and C15 are further regulated by post-linear regulators.
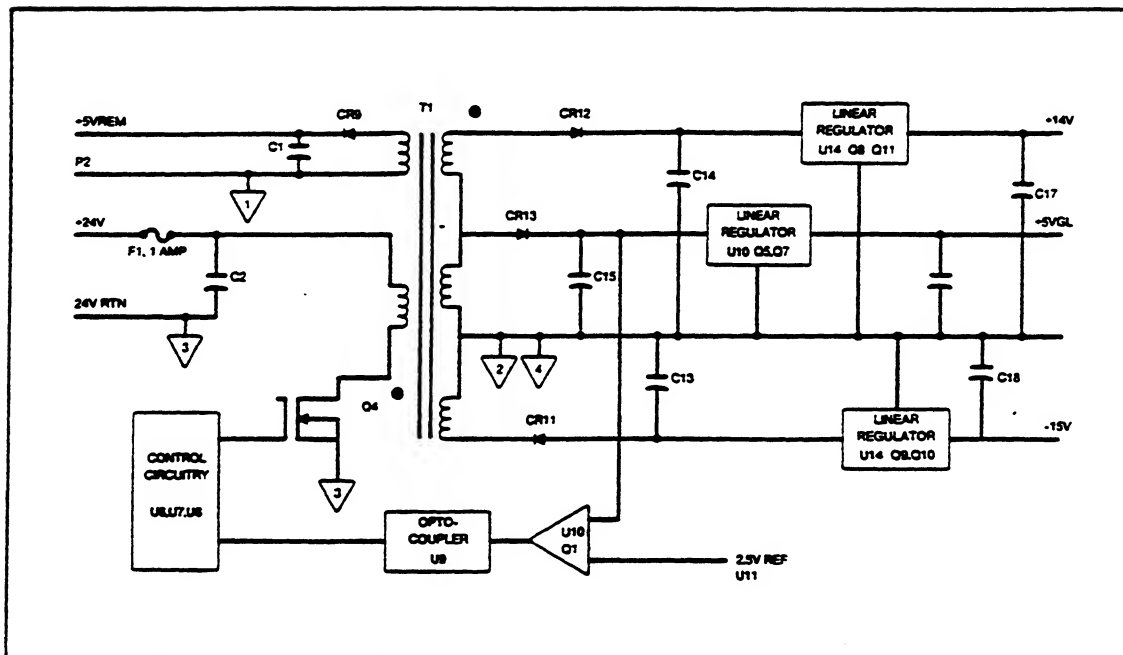
Figure 170-3. Simplified Power Supply Schematic

Control Section

The control section directs the overall activities of the analog output
card. It controls the UART in serial link communications, retrieves the
card address from the decade switches, and delivers the binary number to
the DACs. The major components of the control section are a
microprocessor (U16), a ROM (U18) that contains the program for the
microprocessor, a crystal (Y1) to drive the microprocessor's clock, and
a latch (U25). The address to the ROM consists of eight bits from the
latch (U25) and three bits directly from the microprocessor. The latch
is gated by the address latch enable (ALE) signal from the
microprocessor.

Power-On Reset Circuit

The power-on reset circuit enables the digital circuitry 50 ms or more
after power has been established. It also disables the microprocessor
immediately if the 5VGL decreases below operating level.

The power-on reset circuit is shown in Figure 170-4. Stage 1 of the
power-on reset circuit is the sensing circuit, used to determine if the
output voltage is sufficient for operation. During turn-on, the sensing
circuit releases the RC circuit in the second stage when the power
supply is within tolerance, allowing the RC to charge slowly. If the
voltage across the RC circuit is sufficient, it trips the comparator in
stage 2. When the comparator trips, the POR(L) signal goes high. If on
the other hand, the voltage dips, the output of the comparator in stage
1 goes low, pulling the voltage across the RC circuit low very quickly.
Low voltage across the RC circuit causes the comparator to set the
POR(L) reset signal low.
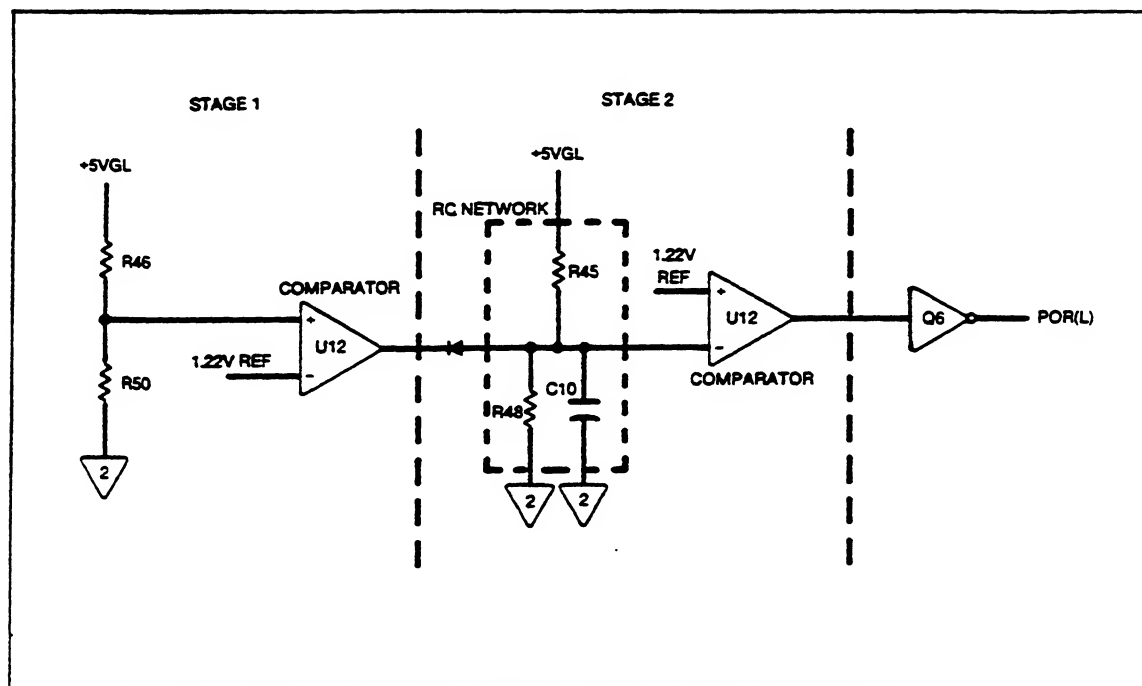
Figure 170-4. Power-On-Reset Simplified Schematic

Communication Circuitry

The communication circuitry is shown in Figure 170-5. Information is received from the serial link by U3, the serial link receiver, and transmitted onto the serial link by U2, the serial link driver. When a data word is received by the UART the DR (data ready) is set, interrupting the microprocessor. The microprocessor reads the UART by enabling the RD signal with port 1, bit 1. By checking port 1, bit 0, the microprocessor checks for three different kinds of errors: overrun error, frame error, and parity errors.

To transmit, the serial link driver is enabled by port 1, bit 3. The microprocessor loads a data word to be transmitted over the serial link by enabling the WR (write) signal to the TBRL (transmit buffer register load). The UART then serially transmits the 8-bit word just loaded from the data bus. The serial link driver is then disabled to allow other boards to use the serial link.

Decade Switches

The analog output address is determined by the position of the decade switches. The decade switches are located on the left-hand side of the board. The value of the decade switch is enabled onto the data bus by the tri-state buffers U19 and U20. The tri-state buffers are controlled by the RD signal from the microprocessor. The RD signal to the buffers
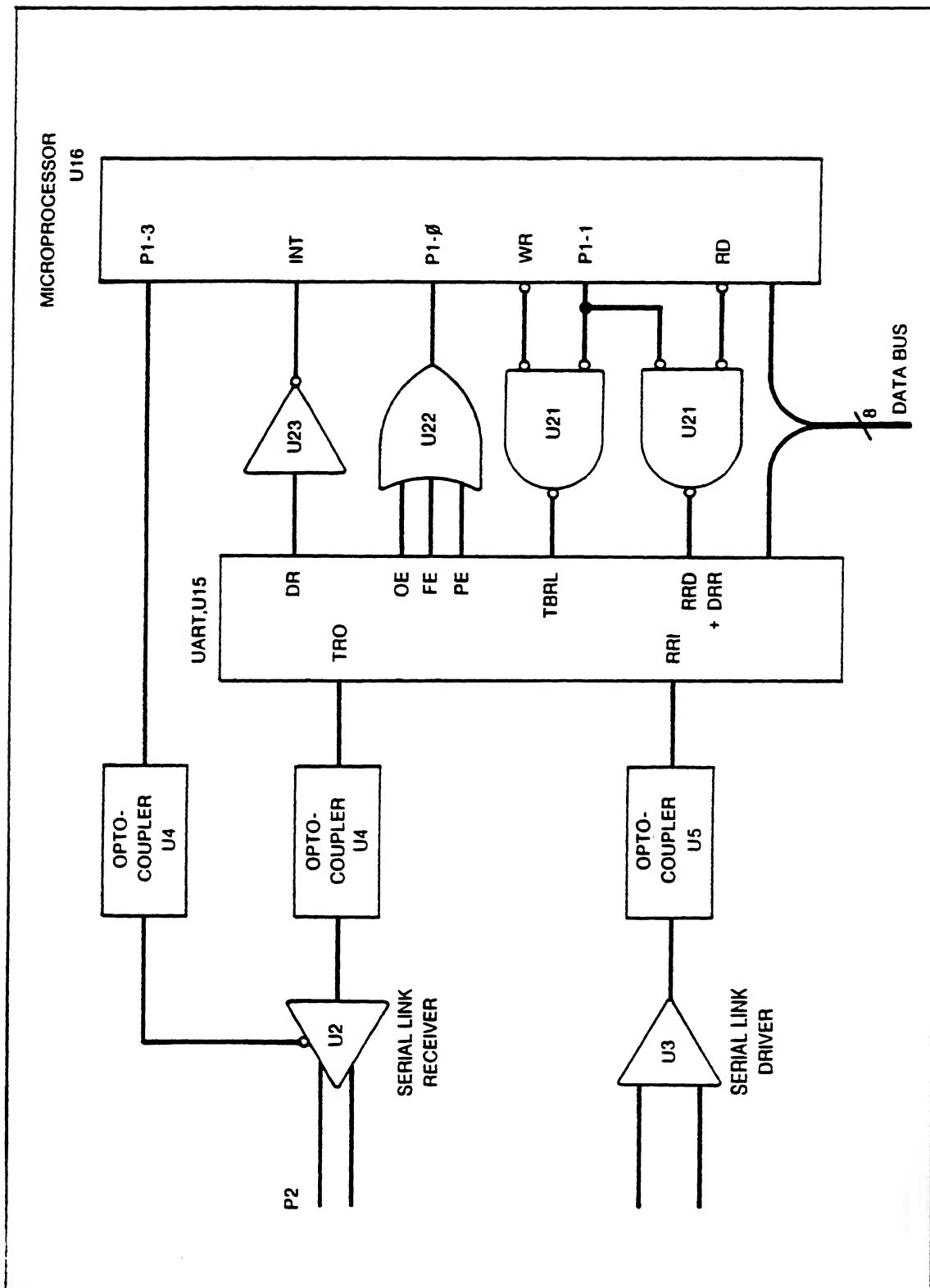
Figure 170-5. Communication Circuitry

is enabled by setting port 1, bit 5, low. Figure 170-6 is a simplified
schematic of the interface between the microprocessor and the decade
switch. The address read from the decade switch is compared to the
address received over the serial link.
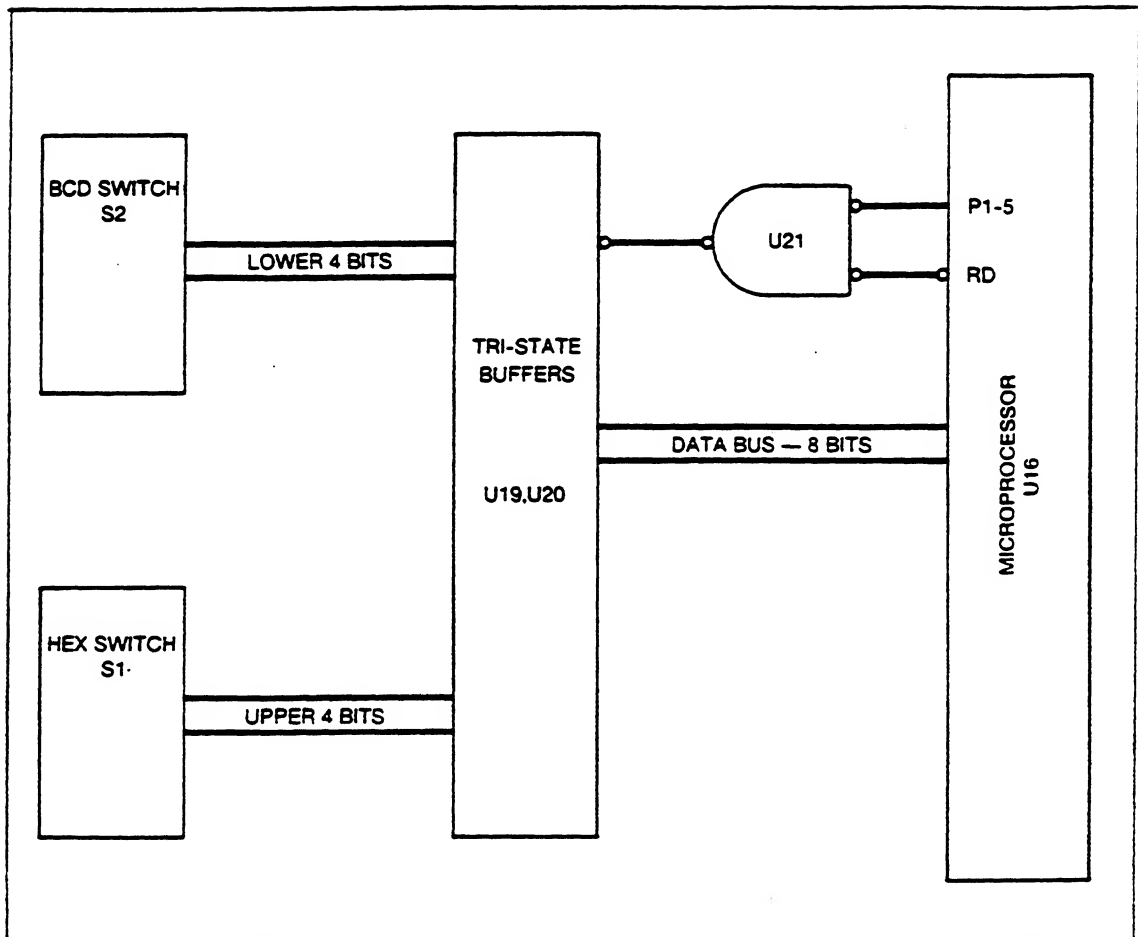
Figure 170-6. Decade Switches To Microprocessor Interface

Note that when checking the address lines for the correct signals, a
value of 1 (true) is indicated by a low voltage on the corresponding
line.

Latch Control

The digital-to-analog converters (DACs) convert a 12-bit digital word to
an analog output. The 12-bit word is built in two steps using latch A,
shown in Figure 170-7. First, an 8-bit data word is latched into U17
from the data bus. Then 4 bits are latched into U24 from the lower 4
bits of port 2. This 12-bit word is then presented to the output channel
selected by port 2, bits 4 through 7, which clock the 12-bit data word
into the appropriate B latch. Table 170-2 lists the port bit that is
used for each channel.

Table 170-2. Channel Port Pins

PORT	BIT	PIN	CHANNEL
2	7	38	0
2	6	37	1
2	5	36	2
2	4	35	3
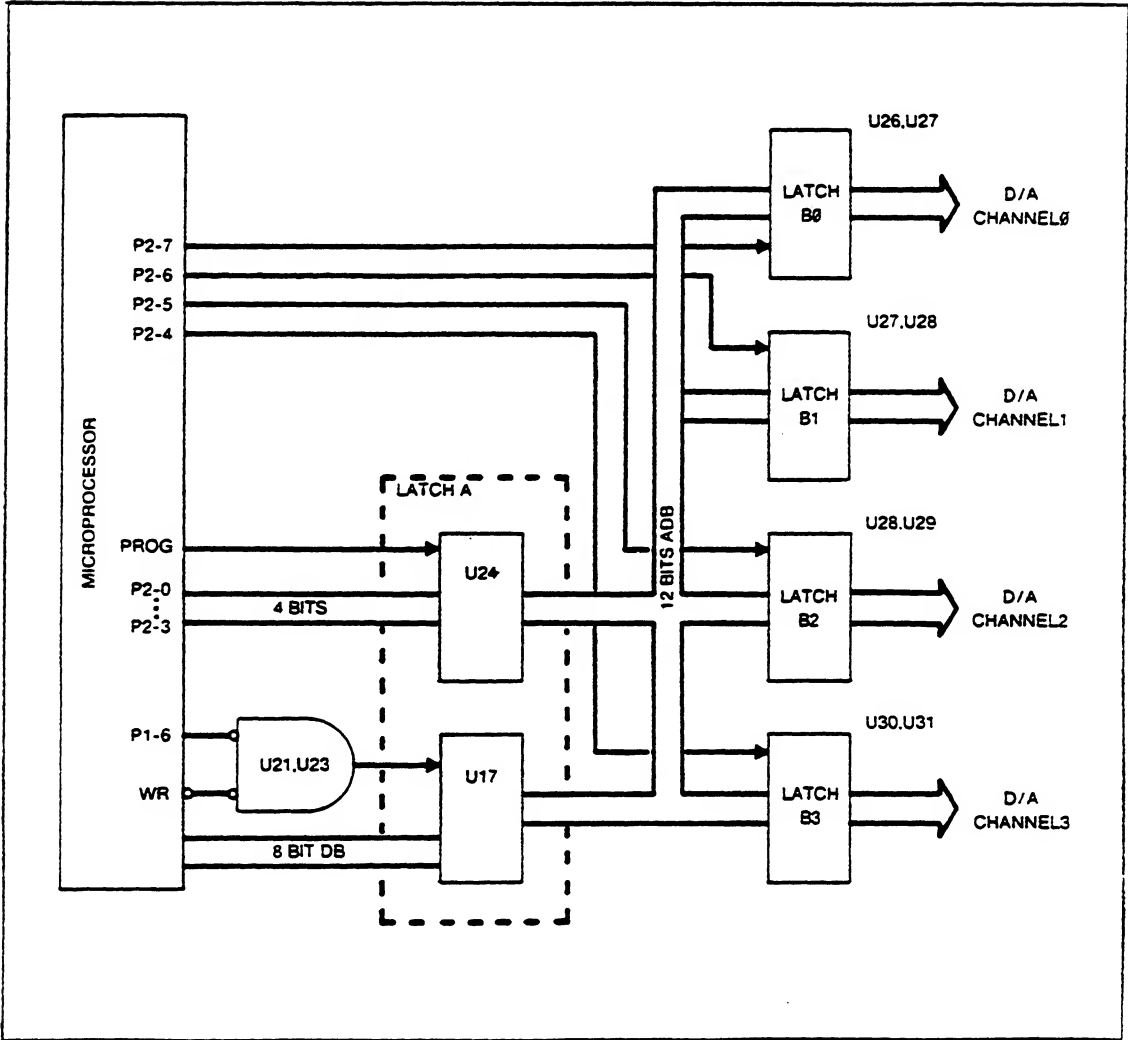
Figure 170-7. Control Circuitry

The output of all four channels is reset to 0% of full scale when port 2, bit 7, is set high. Port 2, bit 7, is high initially when the Analog Output is powered on. This control line is also used to reset the outputs when an initialize or reset command is received from the mainframe.

ANALOG SECTION

The core of the analog section is a voltage reference and DAC with an amplifier. This circuitry is all that is needed for the 0 to 10V output. The bipolar output +5V to -5V is achieved with the addition of a 5V offset. The current source converts the 0 to 10V output and -10V reference to establish the 4- to 20-mA output. The digital-to-analog circuitry is shown in Figure 170-8.
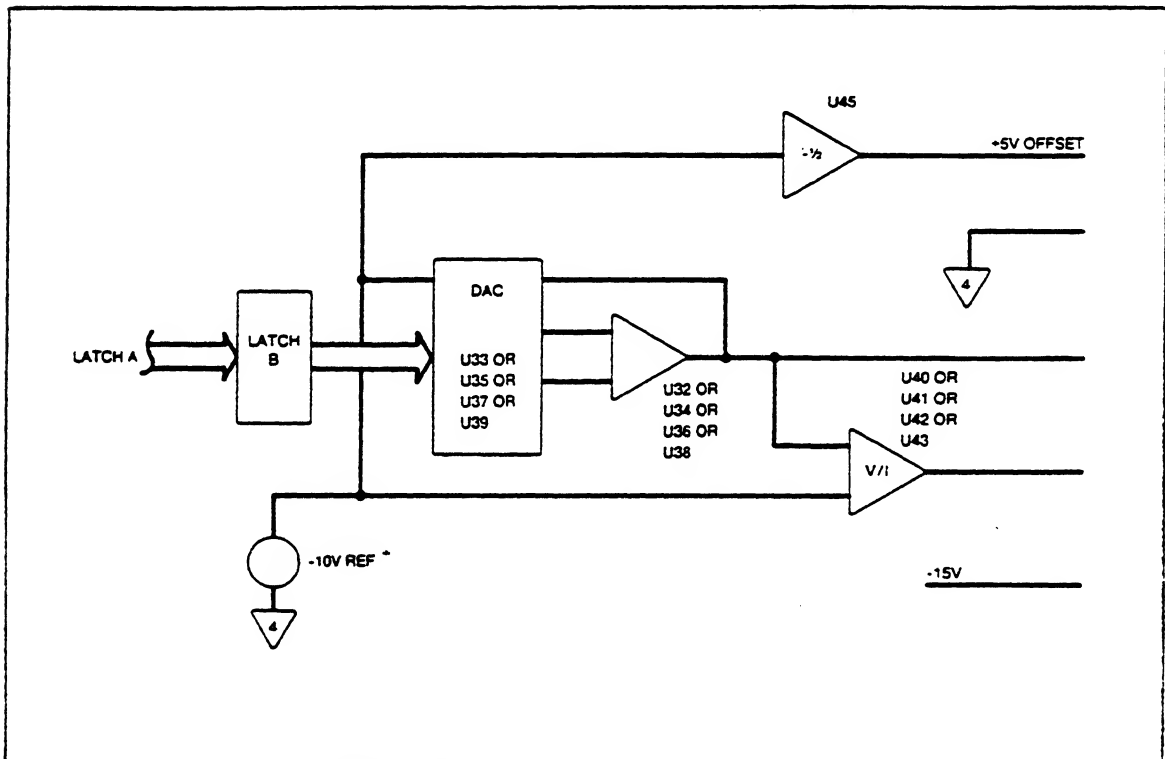
Figure 170-8. Digital-to-Analog Circuitry

-10V Reference

The -10V reference is the main reference for the analog output. The primary components are VR3 and U44. The zener diode is part of a selected set containing VR3, R98, and R106. The resistors are chosen so the voltage on pin 3 of U44 is between -6.2V and -6.45V. This voltage is amplified to -10V by U44, which is configured in a non-inverting mode with a nominal gain of 1.61. Potentiometer R99 adjusts the gain (the -10 volt reference).

5V Offset

The 5V offset is used as the return for the voltage source when the bipolar, -5V to +5V, is desired. The 5V is common to all four channels.

The primary active components are U45, Q27, and Q26. The -10 volt reference is used to drive an inverting amplifier with a gain of -0.5. Q27 and Q26 provide the additional drive necessary to support all four outputs. The potentiometer R100 adjusts the 5V offset.

DAC and Amplifier

The DAC and its amplifier for each channel are shown in Table 170-3. The potentiometer shown adjusts the voltage output of the channel.

Table 170-3. DAC Amplifier Potentiometers

CHANNEL	DAC	AMPLIFIER	POTENTIOMETER
0	U33	U32	R61
1	U35	U34	R64
2	U37	U36	R67
3	U39	U38	R70

Current Source

Figure 170-9 shows the current source. Output current flows through the 100-ohm resistor and the drive transistors to the load. The voltage drop across the 100-ohm sense resistor, and hence, the output current, is set by the output voltage of the operational amplifier. The potential at the inverting node of the amplifier is the result of the 0 to 10V output and the voltage drop across the 100-ohm sense resistor. The amplifier output voltage is set so that the voltage at the non-inverting node is equal to the voltage at the inverting node. This node is offset from ground by the offset circuitry to create the drive for the 4 mA offset.

In normal operation, Q14 (Q17, Q20, Q23) is turned off. The voltage drop is a few millivolts across the 2-kilohm resistor located between the base of the drive transistors and the output of the amplifier. When the load resistance is such that the voltage drop across the load exceeds the compliance range (10V) of the current source, the current flowing from the base of the drive transistors becomes excessive, which causes a voltage drop that approaches one volt. The voltage drop creates enough drive to turn on Q14 (Q17, Q20, Q23), thus connecting the output of the operational amplifier to the inverting node. The voltage output of the amplifier is forced to the offset voltage on the non-inverting node of the amplifier.
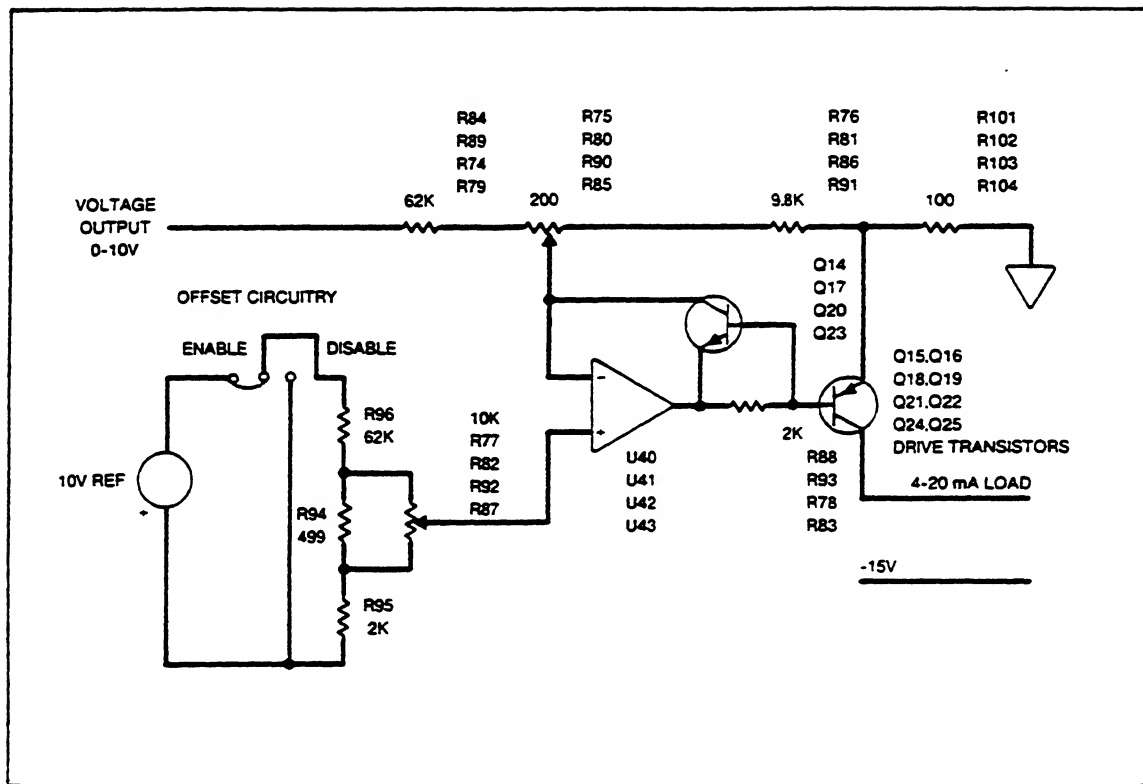
Figure 170-9. The Current Source

GENERAL MAINTENANCE

The -170 Analog Output Assembly normally does not require cleaning unless dirt, dust, or other contamination is visible on the surface of the Analog Output.

If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

Two performance tests are required to verify that the Analog Output Assembly operates properly and meets its accuracy specifications.

These tests are:

o   Address Response Test

o   Accuracy Verification Test

Address Response Test

The Address Response Test verifies that the mainframe controller assembly can communicate properly with the Analog Output. All address switch signals are tested.

To conduct the Address Response Test, perform the following procedure:

WARNING

**THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE
DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL
SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF
THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE
PERFORMING THE FOLLOWING PROCEDURE.**

1.   Switch OFF power to the Front End. Disconnect the ac line cord and
     all other high voltage inputs.

2.   To eliminate addressing conflict, remove all other installed options.

3.   Set the channel decade switches of the Analog Output Assembly to 00,
     and install the assembly in the uppermost option slot of the Front
     End.

4.   Reconnect the ac line cord and switch Front End power ON.

5.   Program the Front End using either a terminal or a computer. (You
     can also run a terminal emulation program to use a computer
     behaving as a terminal.) For ease of testing, a terminal is the
     recommended host.

     Use either PROCEDURE A or PROCEDURE B, depending on whether
     performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected
host, send the following commands to the Front End.

        MODE=TERM <CR>

        RESET CHAN(0..3) <CR>

        LIST CHAN(0..3) <CR>

A channel definition listing in the following form should be
returned for each of four channels (0 through 3).

        aochan(channel number)=unipolv

where "(channel number)" indicates the number of the channel
definition listed.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs will cause the Front End to
perform the required Analog Output tests on selected channel(s).
One program was written for an IBM PC and one for a Fluke 1722A
Instrument Controller.

NOTE

These programs are offered as examples. If you do
not have an IBM PC or a Fluke 1722A Instrument
Controller, enter a program that will run on your
host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"reset chan(0..3)"
100   GOSUB 300
110   REM obtain hardware configuration
120   PRINT #1,"list chan(0..3)"
130   FOR I=0 TO 4
140   LINE INPUT #1,M$
150   PRINT M$;
160   NEXT I
200   END
300   REM wait for message accepted promt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1%
50    OPEN "KB1:"AS OLD FILE 2%
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"reset chan(0..3)"
110   GOSUB 300
120   REM obtain hardware configuration
130   DIM L$(5)
140   PRINT #1,"list chan(0..3)"
150   FOR I%=0 TO 4\INPUT LINE #2,L$(I%)\NEXT I%
160   X%=0
170   PRINT L$(X%)
```

```
180  X%=1
190  PRINT L$(X%)\X%=X%+1
200  IF X%>4 THEN 220
210  GOTO 190
220  END
300  REM wait for message accepted prompt
310  INPUT #2,A$          ·
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

A channel definition listing should be returned for each of four
channels (0 through 3). The number on the top line indicates the
number of channel definitions listed. The returned response should
be:

```
            4
            0,3,0,0,0,0
               ·
               ·
               ·
            3,3,0,0,0,0
```

The number "3" in the second field of each channel definition
listing confirms that the channel is an analog output channel.

7.   Set the analog output channel decade switches to position 01.

8.   Program the Front End to list its hardware configuration for
     channels 10 through 13 by substituting channels 10 through 13 for
     channels 0 through 3 in both the RESET CHAN and DEF CHAN statements
     of step 6.

9.   Repeat steps 7 and 8 for switch settings 02 (channels 20 through
     23), 04 (channels 40 through 43), 08 (channels 80 through 83), 10
     (channels 100 through 103), 20 (channels 200 through 203), 40
     (channels 400 through 403), and 80 (channels 800 through 803).

10. This completes the Address Response Test.

Continue with the Accuracy Verification Test if you are conducting a
complete performance test of the -170 Analog Output Assembly.

Accuracy Verification Test

The Accuracy Verification Test ensures that all analog outputs from the
assembly are within specifications.

If the -170 Analog Output Assembly fails the Accuracy Verification Test,
calibration is normally required. A calibration procedure immediately
follows the performance tests in this subsection.

To conduct the Accuracy Verification Test, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE
DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL
SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF
THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE
PERFORMING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Set the channel decade switches of the Analog Output Assembly to 00, and install the assembly in the uppermost option slot of the Front End.

3. Reconnect the ac line cord to the Front End and switch the power ON.

4. Allow the Front End a warm-up period of about 30 minutes before proceeding.

5. Using a digital multimeter (DMM), verify that the outputs of the Analog Output are within tolerance of their zero percent output values as given in Table 170-4.

CAUTION

The exposed screws on top of the Analog Output
connector block can be probed only if they are
screwed down tightly. Otherwise, contact is not
made with the output from the -170 Assembly.

Table 170-4. Output Values and Tolerances for Zero Percent Outputs

OUTPUT SIGNAL	OUTPUT VALUE	TOLERANCE	TERMINAL PAIR FOR EACH CHANNEL							
			0+	0-	1+	1-	2+	2-	3+	3-
0 to 10V	0.000V	+/- 0.010V	1	2	6	7	11	12	16	17
-5 to +5V	-4.997V	+/- 0.010V	1	3	6	8	11	13	16	18
4 to 20mA	4.000mA	+/- 0.020mA	4	5	9	10	14	15	19	20

6. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.)

For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..3)=UNIPOLV <CR>

FORMAT=DECIMAL <CR>

CHAN(0..3)=10 <CR>
```

A1. Using a DMM, verify that the outputs of the Analog Output are within tolerance of their full scale output values as given below:

OUTPUT VALUE AND TOLERANCE FOR UNIPOLAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel							
		0+	0-	1+	1-	2+	2-	3+	3-
9.997V	+/- 0.010V	1	2	6	7	11	12	16	17

A2. Program the Front End to provide a full scale bipolar voltage source of +5V by sending the following commands:

```
DEF CHAN(0..3)=BIPOLV <CR>

CHAN(0..3)=5 <CR>
```

A3. Using a DMM, verify that the bipolar voltage outputs are within the below stated tolerances:

OUTPUT VALUE AND TOLERANCE FOR BIPLOAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel							
		0+	0-	1+	1-	2+	2-	3+	3-
4.997V	+/- 0.010V	1	3	6	8	11	13	16	18

A4. To provide a full scale direct current output of 20 milliamps send the Front End the following commands:

DEF CHAN(0..3)=DCOUT <CR>

CHAN(0..3)=0.02 <CR>

A5. Use a DMM to verify that the direct current outputs are within the below stated tolerances:

OUTPUT VALUE AND TOLERANCE FOR DC CURRENT FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel							
		0+	0-	1+	1-	2+	2-	3+	3-
19.996mA	+/- 0.020mA	4	5	9	10	14	15	19	20

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs will cause the Front End to perform the required Analog Output tests on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for an IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
100 PRINT #1,"def chan(0..3)=unipolv"
110 GOSUB 300
120 PRINT #1,"chan(0..3)=10"
130 GOSUB 300
140 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:" AS NEW FILE 1%
50   OPEN "KB1:" AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"def chan(0..3)=unipolv"
110  GOSUB 300
120  PRINT #1,"chan(0..3)=10"
130  GOSUB 300
140  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

B1. Using a DMM, verify that the channel outputs are within the
     tolerances below:

OUTPUT VALUE AND TOLERANCE FOR UNIPOLAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+ 0- 1+ 1- 2+ 2- 3+ 3-							
9.997V	+/- 0.010V	1	2	6	7	11	12	16	17

B2. Modify the above program by changing the BASIC statements in
     lines 100 and 120 to:

```
100 PRINT #1,"def chan(0..3)=bipolv"

120 PRINT #1,"chan(0..3)=5"
```

B3. Run the modified program and verify that the channel outputs
     are within the tolerances below:

OUTPUT VALUE AND TOLERANCE FOR BIPLOAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+ 0- 1+ 1- 2+ 2- 3+ 3-							
4.997V	+/- 0.010V	1	3	6	8	11	13	16	18

B4. To verify dc output, again modify the program by changing the
     BASIC statements in lines 100 and 120 to:

```
100 PRINT #1,"def chan(0..3)=dcout"

120 PRINT #1,"chan(0..3)=0.02"
```

B5. Run the modified program and verify that the channel outputs are within the tolerances below:

OUTPUT VALUE AND TOLERANCE FOR DC CURRENT FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+ 0-		1+ 1-		2+ 2-		3+ 3-	
19.996 mA	+/- 0.020 mA	4	5	9	10	14	15	19	20

7. The Accuracy Verification Test for the Analog Output Assembly is complete.

If the -170 Analog Output Assembly fails the Accuracy Verification Test, it should be calibrated.

CALIBRATION

Perform the following procedure to calibrate the -170 Analog Output Assembly.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE PROCEDURES IN THIS SECTION.

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Remove all option modules from the Front End.

3. Install the Calibration/Extender Fixture (Fluke P/N 648741) in the Front End, and mount the Analog Output Assembly on the Calibration/Extender Fixture.

   Be sure to set the Calibration/Extender switch to the EXTEND position.

4. Set the channel decade switch on the rear panel of the Analog Output to 00.

5. Reconnect the Front End ac line cord and switch the power ON.

6. Set the DMM to read +10V with 0.0001V resolution.

7. Connect the positive test lead of the DMM to terminal 21 on the Analog Output connector and connect the negative lead to terminal 2.

8. Calibrate the -10V reference by adjusting R99 such that the voltage measured between connector terminals 2 and 21 is -10.0000V within a tolerance of +/- 0.0005V.

9. Connect the positive test lead of the DMM to terminal 3 on the connector and the negative lead to terminal 2.

10. Calibrate the 5V reference by adjusting R100 so that the voltage measured between connector terminals 2 and 3 is +5.0000V +/- 0.0005V.

11. Set the outputs on channels 0, 1, 2, and 3 to their full scale values. Do so by performing Procedure A through step A1 (Terminal Mode) or Procedure B through B1 (Computer Mode) in Step 6 of the accuracy verification performance test.

12. Calibrate the full scale outputs for channels 0, 1, 2, and 3 by adjusting the appropriate pot for each channel so that the voltage measured is 9.9976V +/- 0.0005V. Refer to Table 170-5 for terminal and adjustment pot identification.

Table 170-5. Full Scale Voltage Calibration Adjustments

CHANNEL	POSITIVE TERMINAL	NEGATIVE TERMINAL	ADJUSTMENT POT
0	1	2	R61
1	6	7	R64
2	11	12	R67
3	16	17	R70

The voltage outputs are now calibrated. If the 4 to 20 mA current outputs are not going to be used, you may skip the current output calibration and proceed with step 19.

13. Power down the Front End, and install the jumper on the Analog Output at W1 (see Figure 170-10) so that pins 3 and 4 are connected. This disables the 4 mA offset.

14. Power up the Front End.

    If using the Terminal Mode, send the command

        MODE=TERM <CR>

    Then perform A4 of step 6 of the Accuracy Verification Test.

    If using the Computer Mode, perform B4 and B5 of step 6 of the accuracy verification performance test.

15. Calibrate the current outputs for channels 0, 1, 2, and 3 by
    adjusting the appropriate pot for each channel so that the current
    measured is 15.996 mA +/- 0.001 mA. Refer to Table 170-6 for
    terminal and adjustment pot identification.

Table 170-6. Full Scale Current Calibration Adjustments (Without Offset)

CHANNEL	POSITIVE TERMINAL	NEGATIVE TERMINAL	ADJUSTMENT POT
0	4	5	R75
1	9	10	R80
2	14	15	R85
3	19	20	R90

16. Power down the Front End return jumper W1 (see Figure 170-10) so
    that pins 1 and 2 are connected. This enables the 4 mA offset.

17. Power up the Front End.

    If using the Terminal Mode, send the command

        MODE=TERM <CR>

    Then perform A4 of step 6 of the accuracy verification performance
    test.

    If using the Computer Mode, perform B4 and B5 of step 6 of the
    accuracy verification performance test.

18. Calibrate the current outputs for channels 0, 1, 2, and 3 by
    adjusting the appropriate pot for each channel so that the current
    measured is 19.996 mA +/- 0.001 mA. Refer to Table 170-7 for
    terminal and adjustment pot identification.

Table 170-7. Full Scale Current Calibration Adjustments (With Offset)

CHANNEL	POSITIVE TERMINAL	NEGATIVE TERMINAL	ADJUSTMENT POT
0	4	5	R77
1	9	10	R82
2	14	15	R87
3	19	20	R92

Figure 170-10. W1 Jumper and Pins
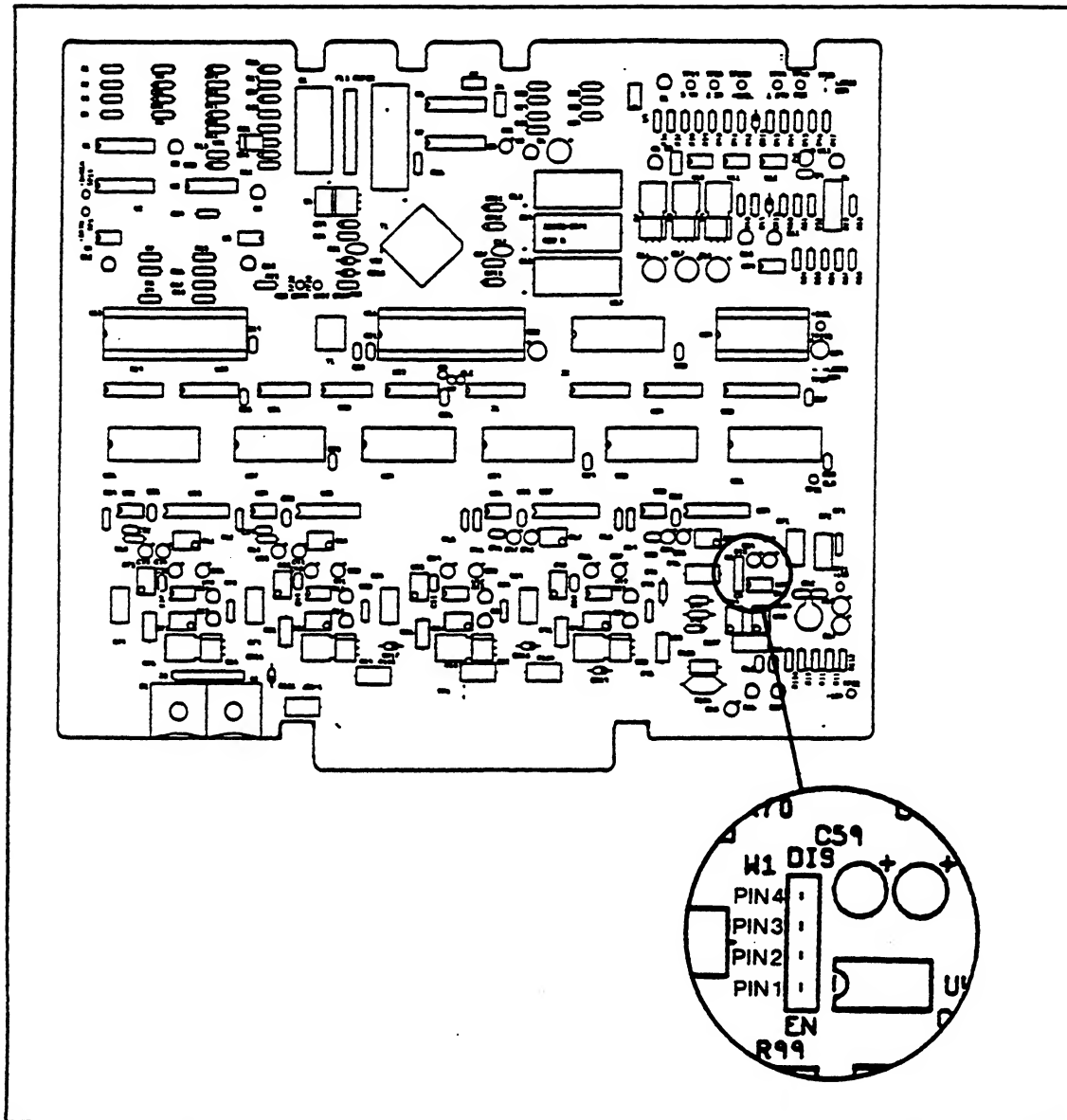
19. The calibration of the Analog Output Option is now complete.

20. Power down the Front End.

    a. Remove the Analog Output from the Calibration/Extender Fixture.

    b. Remove the Calibration/Extender Fixture from the Front End.

21. Install the Analog Output in the Front End or 2281 Extension Chassis, and set the channel decade switch as required by your application.

22. Reinstall the other hardware that may have been removed to calibrate the Analog Output.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Analog Output is given in Table 170-8.

For parts ordering information, see Section 6 of this manual.

Figure 170-11 is a schematic diagram of the Analog Output Option.

TABLE 170-8. -170 ANALOG OUTPUT PCA
(SEE FIGURE 170-11.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	---------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C	1, 13- 15	CAP,AL,270UF,+100-10%,20V	602656	89536	602656	4		
C	2	CAP,AL,330UF,+100-10%,25V	614404	89536	614404	1		
C	3	CAP,CER,5600PF,+-5%,50V,COG	528596	89536	528596	1	•	
C	4	CAP,CER,1000PF,+-5%,50V,COG	528539	51406	RPE113	1		
C	5	CAP,TA,1UF,+-10%,35V	161919	56289	196D010X0035G	1		
C	6	CAP,AL,22UF,+-20%,35V	655084	74840	RLR-PX	1		
C	8	CAP,CER,1.0UF,+-20%,50V,Z5U	434782	72982	8131-050-601-105M	1		
C	9, 19, 23, 25- 30	CAP,CER,0.22UF,+-20%,50V,Z5U	519157 519157	51406	RPE111Z5U224M50V	9		
C	10	CAP,POLYES,0.47UF,+-10%,100V	369124	89536	369124	1		
C	11	CAP,CER,1000PF,+-10%,500V,X5S	357806	56289	C0168102G102K	1		
C	12	CAP,CER,0.0012UF,+-10%,500V,Z5R	106732	71590	CF122	1		
C	14- 18	CAP,AL,47UF,+-20%,16V	643304	89536	643304	3		
C	20	CAP,CER,18PF,+-2%,100V,COG	512335	51406	RD870-100V	1		
C	21	CAP,CER,4.7PF,+-0.25PF,100V,COH	362772	89536	362772	1		
C	22, 24, 59, 60, 66, 67	CAP,TA,15UF,+-20%,20V	519686 519686	56289	196D156X0020KE4	6		
C	31, 38, 45, 52	CAP,CER,2200PF,+-20%,100V,X7R	358291 358291	89536	358291	4		
C	32, 39, 46, 53	CAP,CER,1200PF,+-20%,100V,X7R	358283 358283	72982	8121-A100-W5R-122M	4		
C	33- 36, 40- 43	CAP,TA,2.2UF,+-20%,20V	161927 161927	56289	196D225X0020MA1	17		
C	47- 50, 54- 57, 65		161927 161927					
C	37, 44, 51, 58	CAP,CER,0.01UF,+-20%,100V,X7R	407361 407361	72982	8121-A100-W5R-103M	4		
C	61	CAP,CER,22PF,+-2%,100V,COG	512871	89536	512871	1		
C	62- 64	CAP,CER,120PF,+-2%,100V,COG	543819	04222	SR15	3		
CR	1- 8, 11, 12	• DIODE,SI, 50 PIV, 1.0 AMP	379412 379412	04713	1N4933	10	1	
CR	9, 13	• DIODE,SI, 20 PIV, 1.0 AMP	507731	83003	VSK120	2	1	
CR	10, 16- 19	• DIODE,SI, 100 PIV, 1.0 AMP	343491	01295	1N4002	5	2	
CR	14, 15	• DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	2		
E	1	JUMPER, RECEPTACLE	530253	00079	530153-2	1		
F	1	FUSE,1/4 X 1-1/4,FAST,1.0A,250V	369819	71400	AGC1	1		
H	1	NYLON, STEM:OD=.093", L=.115"	658450	89536	658450	8		
H	2	WASHER	110270	89536	110270	5		
H	2	SCREW,MACH,FHP,STL,6-32X3/8	114363	73734	182444	3		
H	3	SCREW	114223	89536	114223	2		
H	4	WASHER	110692	89536	110692	2		
J	1	POLARIZING INSERT,EDGE CONN. ACCESS.	543710	89536	543710	1		
MP	1	COVER,ANALOG/OUTPUT	729673	89536	729673	1		
MP	2	SPACER,SWAGED,RND,BRASS,6-32X0.250	446351	89536	446351	3		
MP	3	CABLE TIE,4"L,0.100"W,0.75 DIA	172080	89536	172080	2		
MP	4	FUSE HLDR,CLIP,PCB,1/4 DIA FUSE	485219	91833	3529	2		
MP	5	BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1	5	
Q	1, 3, 10, 12, 13, 26	• TRANSISTOR,SI,PNP,SMALL SIGNAL	193974 193974	64713	2N3906	6	1	
Q	4	• TRANSISTOR,SI,N-MOS,POWER,TO-220AB	586107	89536	586107	1	1	
Q	5, 6, 11, 27	• TRANSISTOR,SI,NPN,SMALL SIGNAL	218396 218396	04713	2N3904	4	2	
Q	7, 8, 16, 19, 22, 25	• TRANSISTOR,SI,BV= 80V,100W,TO-202	495689 495689	04713	MPSU56	6	1	
Q	9	• TRANSISTOR,SI,BV= 80V, 10W,TO-202	495697	04713	MPS-U06	1	2	
Q	14, 17, 20, 23	• TRANSISTOR,SI,NPN,SMALL SIGNAL	218081 218081	04714	MPS6520	4	1	
Q	15, 18, 21, 24	• TRANSISTOR,SI,PNP,SMALL SIGNAL	225599 225599	07263	2N4250	4	1	
R	1, 2, 10, 11, 59, 42, 66, 69	RES,CF,51,+-5%,0.25W	414540 414540 414540	80031	CR251-4-5P51E	8		
R	3, 13, 16, 20	RES,CF,5.6K,+-5%,0.25W	442350 442350	80031	CR251-4-5P5K6	4		
R	5, 19	RES,CF,30,+-5%,0.25W	442228	80031	CR251-4-5P30E	2		
R	7, 12, 14, 15, 22	RES,CF,270,+-5%,0.25W	348789 348789	80031	CR251-4-5P270E	5		
R	8, 9, 17, 18, 21, 23, 25, 31, 44, 51	RES,CF,10K,+-5%,0.25W	348839 348839 348839 348839	80031	CR251-4-5P10K	10		
R	24	RES,CF,510,+-5%,0.25W	441600	80031	CR251-4-5P510E	1		
R	26, 36, 41	RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	3		
R	27	RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	1		

TABLE 170-8 -170 ANALOG OUTPUT PCA
(SEE FIGURE 170-10.)

REFERENCE DESIGNATOR A->NUMERICS	S DESCRIPTION	FLUKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	R S -Q	N O T -E
R 28	RES,MF,9.53K,+-1%,0.125W,100PPM	288563	91637	CMF559530F	1		
R 29, 30, 32, 40, 42, 50	RES,MF,10K,+-1%,0.125W,100PPM	148260 148260	91637	CMF551002F	6		
R 33	RES,MF,39.2K,+-1%,0.125W,100PPM	236414	91637	CMF553922F	1		
R 34	RES,MF,14.3K,+-1%,0.125W,100PPM	291617	91637	CMF551432F	1		
R 37	RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	1		
R 38	RES,MF,46.4K,+-1%,0.125W,100PPM	188375	89536	188375	1		
R 39	RES,MF,40.2K,+-1%,0.125W,100PPM	235333	91637	CMF554022F	1		
R 43	RES,CF,8.2K,+-5%,0.25W	441675	80031	CR251-4-5P8K2	1		
R 45	RES,MF,332K,+-1%,0.125W,100PPM	289504	91637	CMF553323F	1		
R 46	RES,MF,28.7K,+-1%,0.125W,100PPM	235176	91637	CMF552872F	1		
R 47	RES,MF,1K,+-1%,0.125W,100PPM	168229	91637	CMF551001F	1		
R 48	RES,MF,154K,+-1%,0.125W,100PPM	289447	91637	CMF551543F	1		
R 49, 52	RES,CF,1M,+-5%,0.25W	348987	80031	CR251-4-5P1M	2		
R 53, 56	RES,MF,2.49K,+-1%,0.125W,100PPM	226209	91637	CMF552491F	2		
R 54, 57	RES,CF,680,+-5%,0.25W	368779	80031	CR251-4-5P200E	2		
R 55	RES,MF,11.5K,+-1%,0.125W,100PPM	267138	91637	CMF551152F	1		
R 58	RES,MF,15K,+-1%,0.125W,100PPM	285296	91637	CMF551502F	1		
R 60, 63, 65, 68	RES,MF,80.6,+-1%,0.125W,100PPM	306969 306969	89536	306969	4		
R 61, 64, 67, 70, 73, 80, 85, 90,100	RES,VAR,CERM,200,+-10%,0.5W	721464 721464 721464	89536	721464	9		
R 71	RES,6.983K(+-.05%0+-3PPM TC 1/4W DODD	292896	89536	292896	1		
R 72	RES,WW,40K,+-0.1%,0.125W	271403	89536	271403	1	1	
R 73,112	RES,CF,22K,+-5%,0.25W	348876	80031	CR251-4-5P22K	2		
R 74, 79, 84, 89, 96	RES,62K(+-.05% 0+-3PPM TC 1/4W DODD	292904 292904	89536	292904	5	1	
R 76, 81, 86, 91	RES,WW,9.8K,+-0.1%,0.15W	446484 446484	89536	446484	4	1	
R 77, 82, 87, 92	RES,VAR,CERM,10K,+-10%,0.5W	485458 485458	32997	3299W-CR2-103	4		
R 78, 83, 88, 93	RES,CF,2K,+-5%,0.25W	441469 441469	80031	CR251-4-5P2K	4		
R 94	RES,MF,499,+-1%,0.125W,100PPM	168211	91637	CMF554990F	1		
R 95	RES, 2.0K(+-.1% 0+-10PPM TC1/4W DODD	243048	89536	243048	1	1	
R 97	RES,MF,61.9K,+-1%,0.125W,25PPM	484923	91637	CMF556192F	1		
R 98,106	ZENER REFERENCE SET	377283 377283	89536	377283	1		
R 3							
R 99	RES,VAR,CERM,500,+-10%,0.5W	520783	32997	3299W-CR2-501	1		
R 101-104	100(	112151	89536	112151	4	1	
R 105	RES,WW,11.35K,+-0.1%,0.15W	385542	89536	385542	1	1	
R 107	RES,WW,20K,+-0.1%,0.125W	271395	89536	271395	1	1	
R 108	RES,CF,4.7K,+-5%,0.25W	348821	01121	C84725	1		
R 109	RES,CF,100,+-5%,0.25W	441436	80031	CR251-4-5P100E	1		
R 110,111	RES,CF,390,+-5%,0.25W	441543	80031	CR251-4-5P390E	2		
S 1	SWITCH,ROTARY,1 POLE,10 POS,1 THUMB	602888	97527	1A-21-60-02-G-F	1	1	
S 2	SWITCH,ROTARY,1 POLE,16 POS,1 THUMB	615096	97527	1A-21-60-33-G-F	1		
T 1	INVERTER,TRANSFORMER	716209	89536	716209	1		
TB 1	CONNECTOR PWB EDGE TERMINAL BLOCK	739995	89536	739995	1		
U 2	• IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	12040	DS1692J	1	1	
U 3	• IC,BPLR,DIFFERENTIAL LINE RECEIVER	586073	01295	SN55182J	1	1	
U 4	• ISOLATOR,OPTO,HI-SPEED,DUAL	429894	28480	5082-4355	1	1	
U 5, 9	• ISOLATOR,OPTO,HI-SPEED,8 PIN DIP	354746	89536	354746	2	1	
U 6	• IC,REGULATING PULSE WIDTH MODULATOR	454678	01295	SG3524N	1	1	
U 7	• IC,CMOS,HEX INVERTER	381848	02735	CD4049AE	1	1	
U 8	• IC,VOLT REG,FIXED,+15 VOLTS,0.1 AMPS	453035	04713	MC78L15ACG	1	1	
U 10, 14	• IC,OP AMP,DUAL,INDUSTRIAL TEMP RANGE	605550	01295	LM258JG	2	1	
U 11	• IC, 2.5 V,40 PPM T.C.,BANDGAP REF	472845	04713	MC1403V	1	1	
U 12	• IC,COMPARATOR,DUAL,LO-PWR,8 PIN DIP	478354	12040	LM393N	1	1	
U 13	• IC, 1.22V,100 PPM T.C.,BANDGAP REF	452771	89536	452771	1	1	
U 15	• IC,CMOS,UNIV ASYNC RECEIVR/TRANSMITER	453464	32293	IM6402CPL	1	1	
U 16	• IC,NMOS,8 BIT MICROCOMPUTER	685529	89536	685529	1	1	
U 17, 26- 31	• IC,CMOS,DUAL 4BIT LTCH W/STROBE&RESET	605261	04713	MC14508BCP	7	1	
U 18	IC,2K X 8 EPROM (PROGRAMMED)	747956	89536	747956	1		
U 19, 20	• IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	2	1	
U 21	• IC,LSTTL,QUAD 2 INPUT OR GATE	605618	01295	SN54LS32J	1	1	
U 22	• IC,CMOS,TRIPLE 3 INPUT OR GATE	408575	02735	CD4075BE	1	1	
U 23	• IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	1		
U 24	• IC,CMOS,QUAD D LATCH,W/XOR ENABLE	355149	02739	CD4042AE	1	1	
U 25	• IC,LSTTL,OCTAL D F/F,+EDG TRG,W/CLEAR	454892	01295	SN74LS273N	1	2	
U 32, 34, 36, 38, 40- 44	• IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980 605980	06665	OP-07DP	9	1	
U 33, 35, 37, 39	• CMOS,12 BIT MULTIPLYING DAC	722264 722264	89536	722264	4	1	
U 45	• IC,OP AMP,GENERAL PURPOSE,TO-78 CASE	418368	89536	418368	1	2	
VR 1	• ZENER,UNCOMP,6V TRANSIENT SUPPRESSOR	508655	24444	1N5908	1	1	
VR 2	• ZENER,UNCOMP, 20.0V, 5%, 12.5MA, 1.0W	291575	12969	UZB720	1	1	
W 1	CONN,PWB,HEADER,SIP,0.100,4 PIN	417329	89536	417329	1		
XU 15, 16	SOCKET,DIP,0.100 CTR,40 PIN	429282	09922	DILB40P-108	2		
XU 18	SOCKET,DIP,0.100 CTR,24 PIN	376236	91506	324-AG39D	1		
Y 1	• CRYSTAL,6MHZ,+-0.01%,HC-18/U	461665	89536	461665	1	1	
Z 1, 2	RES,NET,DIP,16 PIN,15 RES,10K,+-5%	355305	89536	355305	2	1	
Z 3	RES,NET,SIP,10 PIN,9 RES,10K,+-2%	414803	80031	95081002CL	1		
02B 4	CONN,TAB,FASTON,PRESS-IN,0.110 WIDE	512889	02660	62375	3		

DESCRIPTION

The -171 Current Input Connector (shown in Figure 171-1) is a
screw-terminal assembly that mates with the -162 Thermocouple/DC Volts
Scanner through a card-edge connector. Up to 20 channels of current
inputs may be connected to the Current Input Connector.

The Current Input Connector converts current to proportional voltages to
be measured by the A/D Converter in the Front End. The Current Input
Connector connects to the scanner through two 44-pin, card-edge
connectors. The entire connector assembly is enclosed in a plastic
housing that provides protection for the terminal connections and strain
relief for external wiring. When the connector is installed, the
protective housing is attached to the Front End chassis with two
retaining screws on each end of the assembly.

Each Input Connector channel has a precision shunt resistor and two
screw terminals labeled HIGH and LOW (see Figure 171-1). Unlike the
Isothermal and Voltage input connectors, there is no screw terminal for
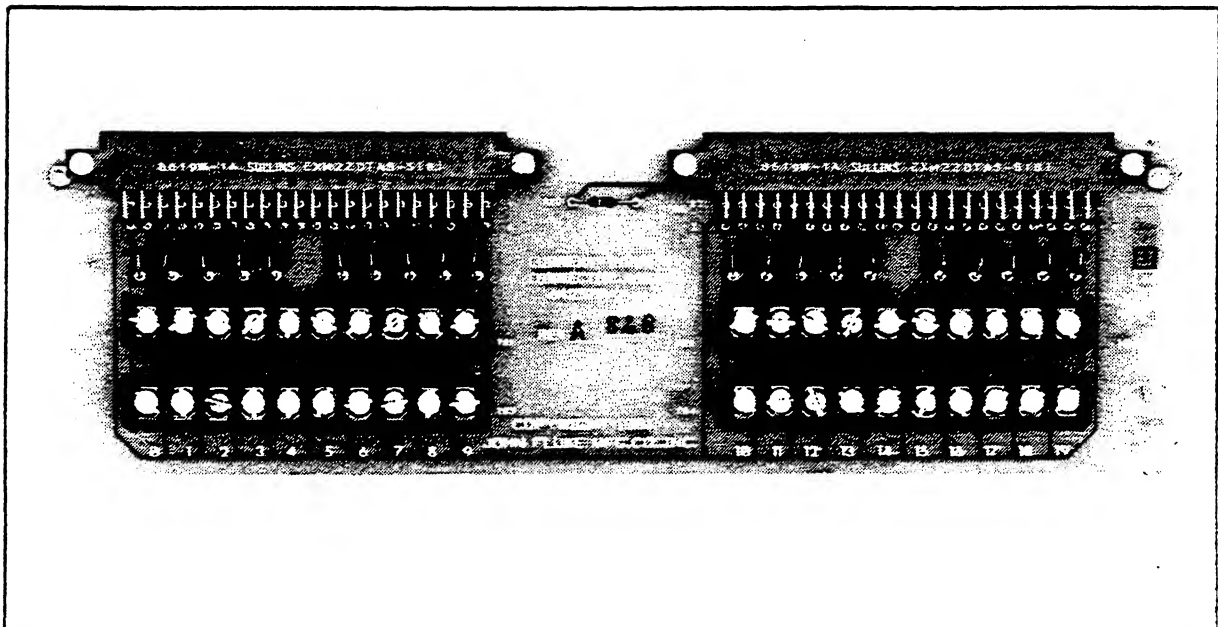shield. The shield is internally connected to the LOW screw terminal.

Figure 171-1. Current Input Connector

171-1

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Current Input Connector theory of operation, performance tests, a parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are found in the Helios I Computer Front End System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 171-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

Table 171-1. Required Test Equipment for -171

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	64 mA +/- 0.25%	Fluke 5100B
Digital Multi-meter (DMM)	Capable of measuring re-sistance in four wire configuration	Fluke 8840A
High Performance A/D Converter	NA	Fluke Option -161
Thermocouple/DC Volts Scanner	NA	Fluke Option -162

THEORY OF OPERATION

The Current Input Connector theory of operation includes a functional description and a circuit analysis. A schematic diagram is at the end of this subsection.

Functional Description

The Current Input Connector receives dc currents through screw terminals and passes them through precision shunt resistors to produce dc voltages proportional to the current inputs. The dc voltages are routed through the Thermocouple/DC Volts Scanner to the A/D Converter, where they are digitized.

Circuit Analysis

Up to 20 dc current sources can be attached to the -171 Current Input Connector through two screw terminals per channel: HI and LO. DC current flows into the HI screw terminal, through an 8-ohm, .7W, 0.25% tolerance shunt resistor, and out the LO screw terminal. On command from the Front end, the resulting dc voltage that appears across the resistor is applied, through the Thermocouple/DC Volts Scanner to the A/D Converter, where the voltage is converted to a digital value.

GENERAL MAINTENANCE

The -171 Current Input Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the instructions in Section 4 of this manual.

PERFORMANCE TEST

The following test verifies that the -171 Current Input Connector is fully operational. This procedure can be used as an initial acceptance test or as a troubleshooting aid.

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to 0, and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner in the option slot immediately below the A/D Converter.

3. Connect test leads to the HI and LO terminals for channel 0 on the Current Input Connector. Install the Current Input Connector on the Thermocouple/DC Volts Scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the test lead from the Current Input Connector HI terminal to the calibrator HI output. Connect the calibrator LO terminal to the Current Input Connector LO test lead.

6. Set the calibrator output to 63.000 mA dc.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

    MODE=TERM <CR>

    DEF CHAN(0..19)=DCIN <CR>

    FORMAT=DECIMAL <CR>

    SEND CHAN(0) <CR>

Verify that the value returned for the selected channel is between 6.28000E-02 and 6.32000E-02 (63 +/- 0.2 mA).

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc current measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
100   GOSUB 300
110   PRINT #1,"def chan(0..19)=dcin"
120   GOSUB 300
```

```
130   PRINT #1,"format=decimal"
140   GOSUB 300
150   REM make measurement and read in response
160   PRINT #1,"send chan(0..19)"
170   FOR I=0 TO 19
180   INPUT #1,M$
190   PRINT "chan";I;"=";
200   PRINT USING "###.##";VAL(M$)*1000;
210   PRINT " milliamps"
220   NEXT I
230   END
300   REM wait for message accepted promt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program for 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1
50    OPEN "KB1:"AS OLD FILE 2
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"count=off"
110   GOSUB 300
120   PRINT #1,"def chan(0..19)=dcin"
130   GOSUB 300
140   PRINT #1,"format=decimal"
150   GOSUB 300
160   REM make measurement and read in response
170   DIM M$(20)
180   PRINT #1,"send chan(0..19)"
190   FOR I%=0 TO 19\INPUT #2,M$(I%)\NEXT I%
200   X%=0\I%=0
210   FOR C%=0 TO 1
220   PRINT TAB(35*C%);"chan";I%;"=";
230   PRINT USING "S###.##",VAL(M$(X%))*1000;\PRINT " milliamps";
240   X%=X%+1\I%=I%+1\IF X%>19 THEN 270
250   NEXT C%
260   GOTO 210
270   END
300   REM wait for message accepted prompt
310   INPUT #2,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

The value returned for the selected channel should be 63 +/- 0.2 mA.

8. Set the calibrator output to 0. Move the test leads of the Current Input Connector to the terminals for the next channel to be tested.

9. Repeat steps 6 through 8 for each remaining current input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

10. Performance testing of the Current Input Connector is complete.

CALIBRATION

The Current Input Connector requires no calibration.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Current Input Connector is given in Table 171-2.

For parts ordering information, see Section 6 of this manual.

Figure 171-2 is a schematic diagram of the Current Input Connector.

TABLE 171-2. CURRENT INPUT CONNECTOR
(SEE FIGURE 171-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	-------DESCRIPTION------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
H 1		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	4		
H 2		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4		
MP 1		CONNECTOR HOUSING, TOP	578971	89536	578971	1		
MP 2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1		
MP 3		DECAL, CURRENT INPUT CONNECTOR	634576	89536	634576	1		
MP 4		DECAL, OPTION -171	634501	89536	634501	1		
MP 5		TAPE,FOAM,PVC,1/4W, 3/8 THK	601134	89536	601134	2		
P 36, 37		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2		
R 1- 19		RES,WW,8,+-0.25%,0.7W	641449	89536	641449	20		
R 20		RES,CF,3.9K,+-5%,0.25W	342600	80031	CR251-4-5P3K9	1	4	
TB 1- 4		SINGLE ROW, .325 CENTERS, 10 POSITION	615328	89536	615328	4		

MP3

MP1

MP4

MP2

2280A-171
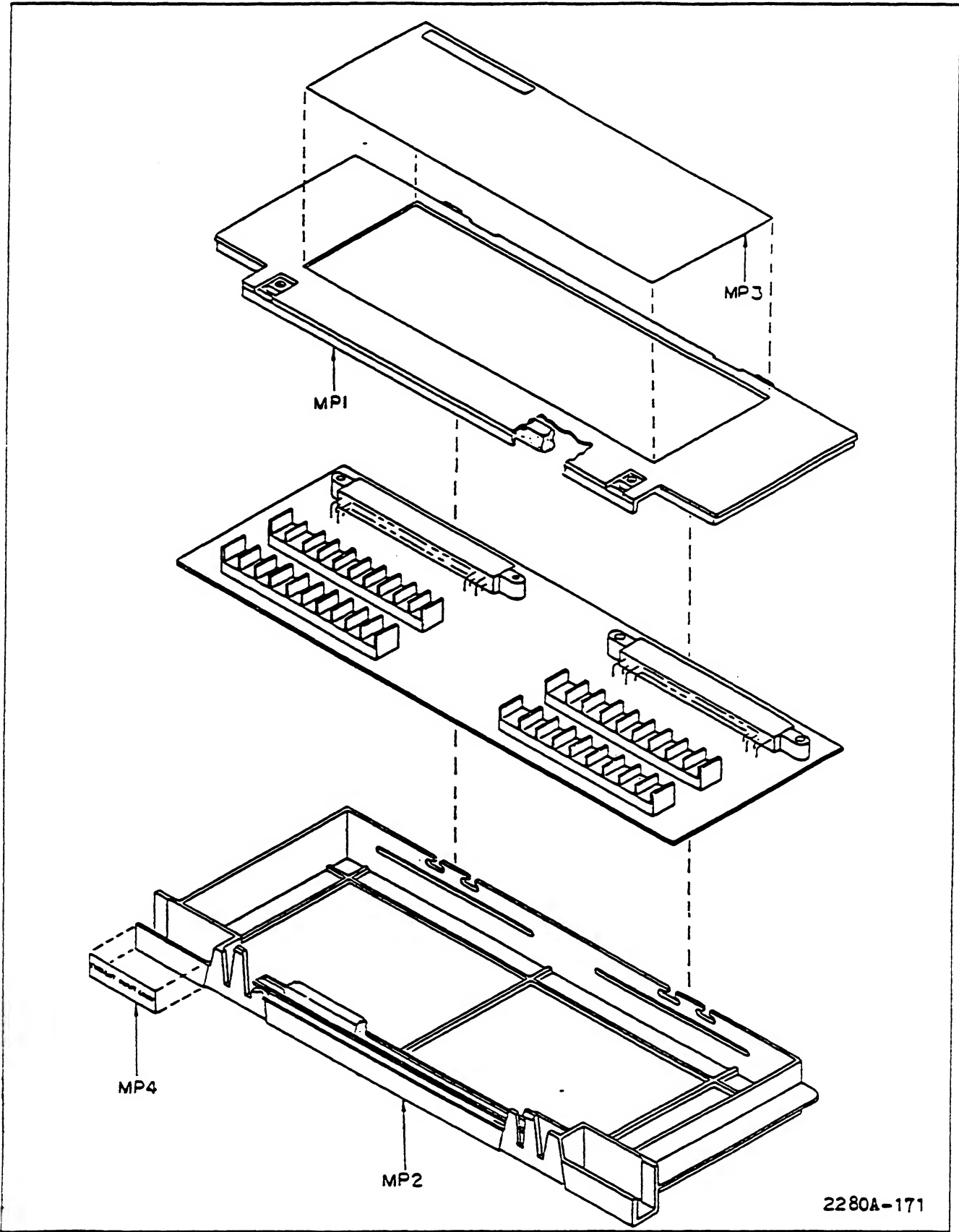
Figure 171-2. -171 Current Input Connector

DESCRIPTION

The -174 Transducer Excitation Connector (shown in Figure 174-1), mounts on the Transducer Excitation Module (-164) and provides it with screw-terminal connections for voltage and current sources.

The combination of the -164 and -174 options allows the Front End to make RTD temperature measurements, strain gauge measurements, strain-based transducer measurements, and low resistance transducer measurements.

Five connecting terminals are available for each channel, and twenty sets of these terminals are provided on each input connector. Wiring for each set of terminals is defined by the mode (4-Wire, 3-Wire Accurate, or 3-Wire Common) selected for the Transducer Excitation Scanner. Refer to Section 3B of the Helios I System Manual for wiring instructions.
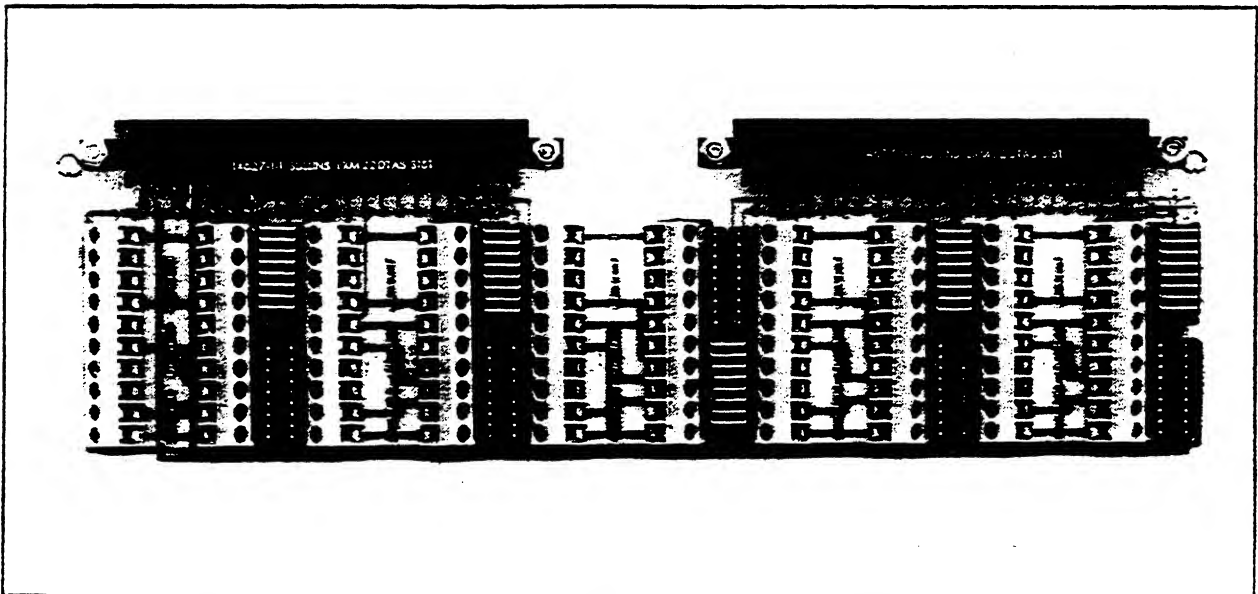

Figure 174-1. Transducer Excitation Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Transducer Excitation Connector theory of operation, a replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are found in the Helios I System Manual. Option specifications are found in the appendices to this manual and in the System Manual.

THEORY OF OPERATION

The Transducer Excitation Connector provides a path from screw terminals on the connector to the card-edge connector pins on the -164 Transducer Excitation Module.

Jumpers on the connector select either current or voltage excitation mode. The jumpers are set to current excitation when the connector is shipped from the factory. Section 3B of the Helios I System Manual contains instructions for connector configuration.

GENERAL MAINTENANCE

The Transducer Excitation Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on the surface. If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

There is no separate performance test for the Transducer Excitation Connector.

The connector is tested during the performance testing of the Transducer Excitation Module. Refer to the -164 Transducer Excitation Module subsection earlier in Section 8.

CALIBRATION

There are no calibration adjustments for the Transducer Excitation Connector.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Transducer Excitation Connector is given in Table 174-1.

For parts ordering information, see Section 6 of this manual.

Figure 174-2 is a schematic diagram of the Transducer Excitation Connector.

TABLE 174-1 TRANSDUCER EXCITATION CONNECTOR
(SEE FIGURE 174-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
H 1		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4		
H 2		STEEL,CAD,PLATED,.125X .500	276493	89536	276493	4		
JR 1I 2I 3I		HEADER,DIP,PROGRAMMED,18 PIN	715227	89536*	715227	5		
JR 4I 5I			715227					
MP 1		CONNECTOR HOUSING, TOP	578971	89536	578971	1		
MP 2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1		
MP 3		DECAL, TRANSDUCER EXCITATION CONN	722041	89536	722041	1		
MP 4		DECAL, OPTION -174	722058	89536	722058	1		
MP 5		TAPE,FOAM,PVC,1/4W,3/8 THK	603134	89536	603134	2		
P 54, 55		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2		
TB 1- 10		TERM STRIP,PWB,ANGL ENTRY,10 CONTACTS	501403	89536	501403	10		
XJR 1- 5		SOCKET,DIP,0.100 CTR,18 PIN	418228	91506	318-AG39D	10		
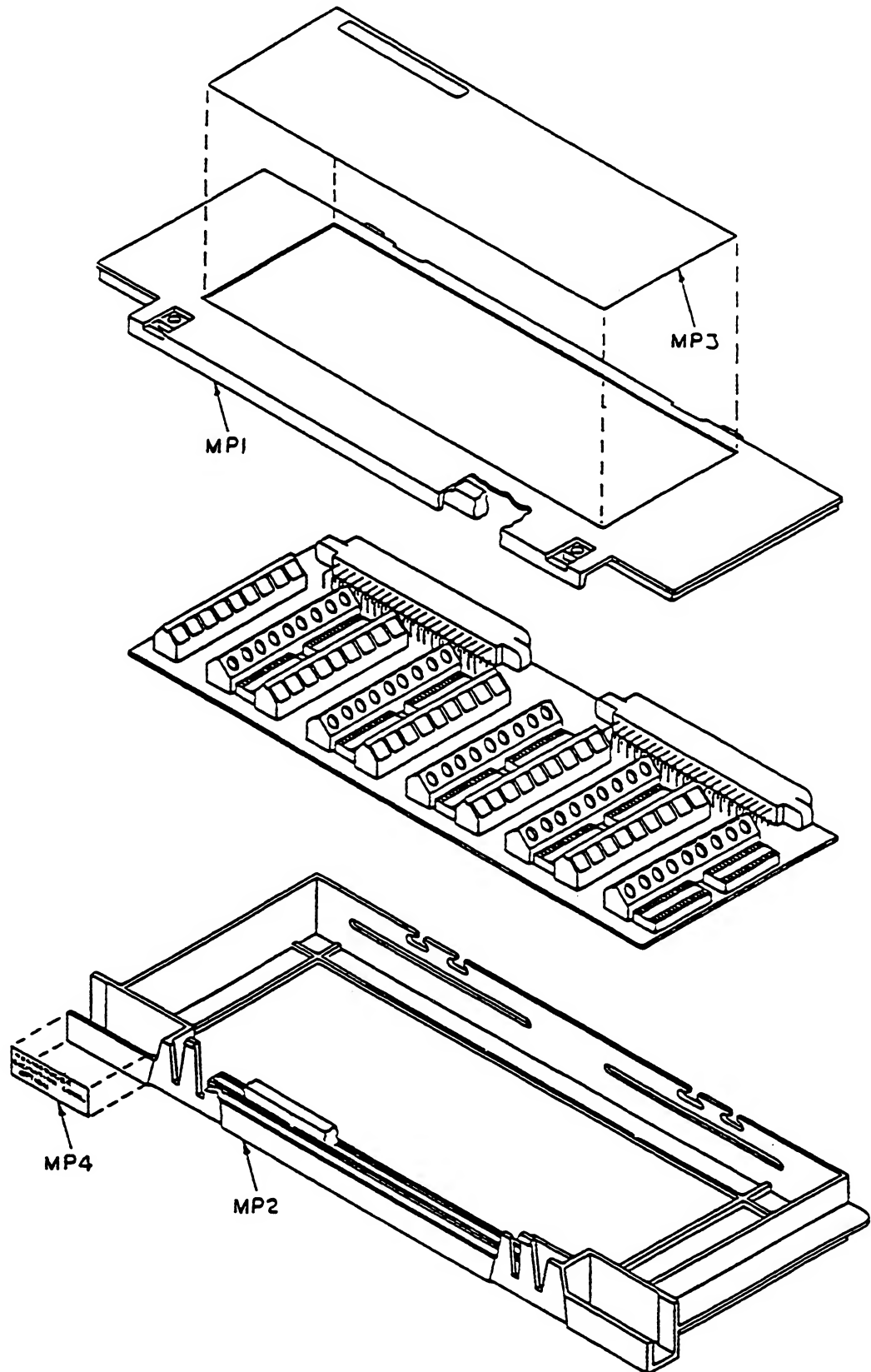
Figure 174-2. -174 Transducer Excitation Connector

2280A-174

DESCRIPTION

The -175 Isothermal Input Connector (shown in Figure 175-1) is a card-edge connector assembly that allows up to 20 channels of thermocouple or voltage input to be connected to the -162 Thermocouple/DC Volts Scanner. The Isothermal Input Connector connects to the scanner through two 44-pin card-edge connectors.
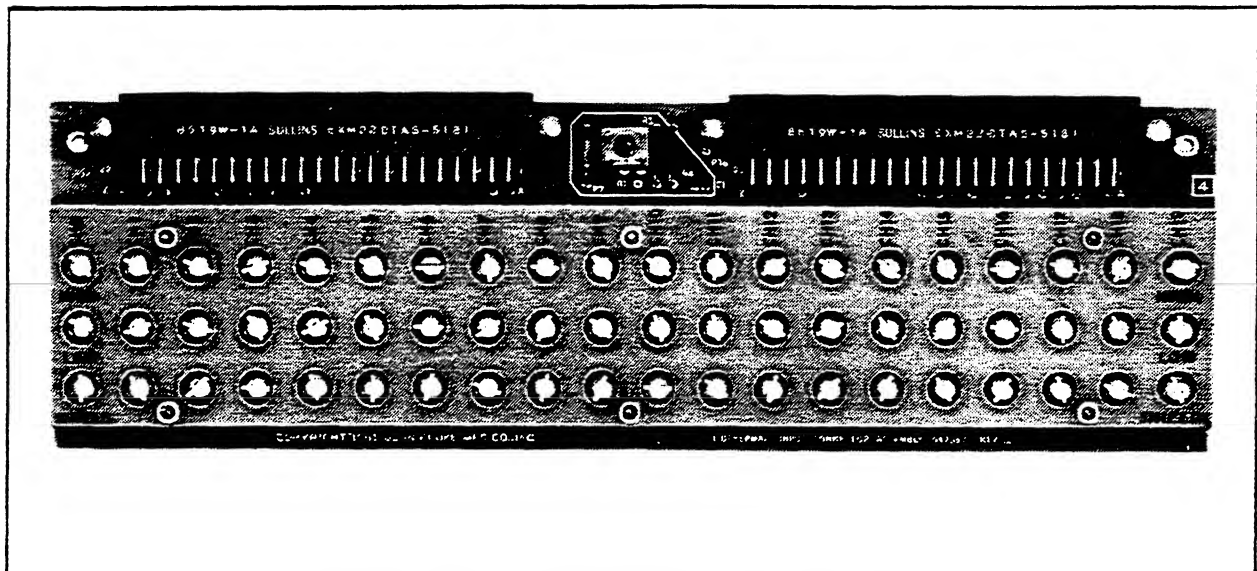
Figure 175-1. Isothermal Input Connector

The entire connector assembly is enclosed in a plastic connector housing that provides protection for terminal connections and strain relief for external wiring. When installed, the housing is attached to the Front End chassis with retaining screws on each side.

There are three screw terminals per channel: HIGH, LOW, and SHIELD. All channel terminals maintain 250V rms separation, and all terminals are surrounded by a block of aluminum that helps to maintain a uniform temperature among the terminals. A temperature sensor mounted in the isothermal block returns temperature readings to the Front End through the Thermocouple/DC Volts Scanner and the A/D Converter.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: -175 Isothermal Input Connector theory of operation, performance tests, calibration procedures, a parts list, and schematics.

Installation, operating, and system configuration instructions are given in the Helios I System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 175-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2.

Table 175-1. Required Test Equipment for -175

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
High Performance A/D Converter	NA	Fluke Option -161
Thermocouple/DC Volts Scanner	NA	Fluke Option -162
Room Temperature Oil/Water Bath	NA	NA
Mercury Thermo-meter	0.02 degrees Celsius Resolution	Princo ASTM-56C
Thermocouple	Type J or K	Fluke P-20J or P-20K

THEORY OF OPERATION

The Isothermal Input Connector theory of operation includes a functional description and a detailed circuit description. The schematic diagram for this assembly is given at the end of this subsection.

Functional Description

By providing connections for up to 20 thermocouples through its screw terminals, the Isothermal Input Connector allows the Front End to make stable temperature readings. The assembly contains a temperature

sensor that measures the isothermal block temperature, allowing automatic reference-junction compensation of thermocouple inputs. The isothermal aluminum block (that surrounds the terminals on the connector) maintains the terminals, input leads, and reference junction at the same temperature.

The Isothermal Input Assembly, when installed on the Thermocouple/DC Volts Scanner, changes the type code of the scanner, thereby signaling the mainframe to permit thermocouple measurements on the channels associated with that scanner and Isothermal Input Connector.

Detailed Circuit Description

TERMINAL CIRCUIT

There are three terminals for each channel, one each for the high input (HI), the low input (LO), and shield (SHIELD). The terminals provide termination points for the wiring that carries incoming dc voltages from thermocouples or voltage sources. The incoming voltages are passed through the Isothermal Input Connector to the Thermocouple/DC Volts Scanner, where channels are selected and conditioned for conversion by the A/D Converter.

REFERENCE JUNCTION CIRCUIT

The temperature of the isothermal terminal block is sensed by the base-emitter junction of transistor Q1. Bias voltage is supplied to the transistor by the A/D Converter +6.2V reference voltage, which is passed through the Thermocouple/DC Volts Scanner and divided down by factory-chosen resistors. The Q1 base-emitter voltage of approximately 600 mV is divided in half by R3 and R4, with the 300 mV output of the divider supplied to the Thermocouple/DC Volts Scanner. The scanner and the A/D Converter measure this signal on the 512-mV range each time a thermocouple measurement is made on the associated input channels, thereby providing a measurement to the Front End for thermocouple linearization processes. Capacitor C1 reduces the sensor's susceptibility to electromagnetic interference (EMI), and resistor R5 provides a bias current return path.

GENERAL MAINTENANCE

The -175 Isothermal Input Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the instructions in Section 4 of this manual.

PERFORMANCE TESTS

The following performance test can be used to verify that the Isothermal Input Connector is functioning properly. The performance test can also be used as an initial acceptance test.

The performance test is divided into two parts: a Channel Integrity Test, which verifies that all channels on the connector are functional; and an Accuracy Verification Test, which verifies that the connector channels meet accuracy specifications. Each test may be performed independently. However, both parts must be performed to test the Isothermal Input Connector fully.

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

Channel Integrity Test

To conduct the Channel Integrity Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the address switch on the A/D Converter to 0.

    (If necessary, refer to subsection 3B of the Helios I System Manual for switch setting instructions).

    A. Install the A/D Converter in the top option slot of the Front End.

    B. Install the -162 Thermocouple/DC Volts Scanner in the slot immediately below the A/D Converter.

3. Connect a shorting wire between HI and LO terminals for channel 0 on the Isothermal Input Connector.

    Remove connections to all other isothermal connector terminals.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

    Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

    MODE=TERM <CR>

    DEF CHAN(0..19)=TC,TYPE=JNBS <CR>

    FORMAT=DECIMAL <CR>

    TUNIT=CELSIUS <CR>

    SEND CHAN(0) <CR>

The value returned for the selected shorted channel should be approximately the ambient temperature.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a temperature measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
100   GOSUB 300
120   PRINT #1,"def chan(0..19)=tc,type=jnbs"
130   GOSUB 300
140   PRINT #1,"format=decimal"
150   GOSUB 300
160   PRINT #1,"tunit=celsius"
170   GOSUB 300
180   REM make measurement and read in response
```

```
190    PRINT #1,"send chan(0..19)"
200    FOR I=C TO 19
210    INPUT #1,T$
220    PRINT "chan";I;"=";
230    PRINT USING "###.#";VAL(T$);
240    PRINT " degrees"
250    NEXT I
260    END
300    REM wait for message accepted prompt
310    INPUT #1,A$
320    IF A$<>"!" THEN GOTO 310
330    RETURN
```

Program for 1722A:

```
10     CLOSE 1,2
20     PRINT CHR$(27);"[2J";
30     REM open communication port and empty Front End buffer
40     OPEN "KB1:"AS NEW FILE 1%
50     OPEN "KB1:"AS OLD FILE 2%
60     PRINT #1,CHR$(3);
70     REM set up Computer Front End
80     PRINT #1,"mode=comp"
90     GOSUB 300
100    PRINT #1,"count=off"
110    GOSUB 300
120    PRINT #1,"def chan(0..19)=tc,type=jnbs"
130    GOSUB 300
140    PRINT #1,"format=decimal"
150    GOSUB 300
160    PRINT #1,"tunit=celsius"
170    GOSUB 300
180    REM make measurement and read in response
190    DIM T$(20)
200    PRINT #1,"send chan(0..19)"
210    FOR I%=0 TO 19\INPUT #2,T$(I%)\NEXT I%
220    X%=0\I%=0
230    FOR C%=0 TO 1
240    PRINT TAB(35*C%);"chan";I%;"=";
250    PRINT USING "S###.#",VAL(T$(X%));\PRINT" degrees";
260    X%=X%+1\I%=I%+1\IF X%>19 THEN 290
270    NEXT C%
280    GOTO 230
290    END
300    REM wait for message accepted prompt
310    INPUT #2,A$
320    IF A$<>"!" THEN GOTO 310
330    RETURN
```

The value returned for the selected shorted channel(s) should be
approximately the ambient temperature.

6. Remove the shorting wire and reconnect it to the terminals for the next channel to be tested.

7. Repeat steps 5 and 6 for each remaining voltage input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

8. This completes the Channel Integrity Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the Isothermal Input Connector and you have not already performed the test on either the A/D Converter or the Thermocouple/DC Volts Scanner.

Accuracy Verification Test

To conduct the Accuracy Verification test, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE PROCEDURES IN THIS SECTION.

1. Switch OFF power to the Front End. Disconnect the line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volt Scanner in the option slot immediately below.

3. Connect a JNBS thermocouple to the HI and LO terminals for channel 11 on the Isothermal Input Connector. Install the connector on the scanner.

NOTE

If other than a J type thermocouple is used, be sure that the TYPE parameter of the DEF CHAN command is consistent with the type of thermocouple being used.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Insert the thermocouple and a mercury thermometer in a room temperature bath, and allow 20 minutes for thermal stabilization.

6.   Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

    MODE=TERM <CR>

    DEF CHAN(11)=TC,TYPE=JNBS <CR>

    FORMAT=DECIMAL <CR>

    TUNIT=CELSIUS <CR>

    SEND CHAN(11) <CR>

The value displayed for channel 11 should be the temperature of the room temperature bath (within the tolerances in Table 175-2) as measured by the mercury thermometer. If the temperature measurement returned for channel 11 does not fall within these tolerances, refer to the calibration procedures, following PROCEDURE B.

Table 175-2. Thermocouple Accuracy Specifications

THERMOCOUPLE TYPE	90 DAYS @ 15-35 DEGREES C	1 YEAR @ 15-35 DEGREES C
JNBS	.35	.4
KNBS	.35	.4
TNBS	.35	.4
ENBS	.35	.4
RNBS	1.15	1.35
SNBS	1.15	1.35
BNBS	1.05	1.25
JDIN	.35	.4
TDIN	.35	.4
NNBS	.35	.4
C	.85	1.05

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a
temperature measurement on the selected channel(s). One program was
written for an IBM PC and one for a Fluke 1722A Instrument
Controller.

NOTE

These programs are offered as examples. If you do
not have an IBM PC or a Fluke 1722A Instrument
Controller, enter a program that will run on your
host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port and empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
110  PRINT #1,"def chan(11)=tc,type=jnbs"
120  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  PRINT #1,"tunit=celsius"
160  GOSUB 300
170  REM make measurement and read in response
180  PRINT #1,"send chan(11)"
190  INPUT #1,T$
200  PRINT USING "###.##";VAL(T$)
210  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up computer Front End
```

```
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(11)=tc,type=jnbs"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  PRINT #1,"tunit=celsius"
170  GOSUB 300
180  REM make measurement and read in response
190  PRINT #1,"send chan(11)"
200  INPUT #2,T$
210  PRINT USING "S###.##",VAL(T$)
220  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value returned for channel 11 should be the temperature of the room temperature bath (within the tolerances shown in Table 175-2) as measured by the mercury thermometer.

7.   The Accuracy Verification Test is complete.

If thermocouple readings taken in the Accuracy Verification Tests are not within tolerance, calibrate the Thermocouple Input Connector.

CALIBRATION

To calibrate the Thermocouple Input Connector, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE PROCEDURES IN THIS SECTION.

1.   Perform steps 1 through 6 of the Accuracy Verfication Test (if you have not already done so).

2.   Take measurement readings (as described in PROCEDURE A or B of the Accuracy Verification Test), and adjust resistor R1 on the Thermocouple Input Connector until the Front End returns the same temperature reading as the mercury thermometer.

In the Terminal Mode, repetitive measurements on a selected channel can easily be taken by sending the repeat command

    ! <CR>

to the Front End each time you want to repeat the measurement.

In the Computer Mode, repetitive measurements on a selected channel can be taken by modifying the loop in the Accuracy Verification Test program of Step 6 as follows:

a. To modify the IBM PC program, change statement 210 to read

    210 GOTO 180

b. To modify the Fluke 1722A program, change statement 220 to read

    220 GOTO 190

Measurements on the selected channel(s) will now be continuously taken and displayed until the program is interrupted by the appropriate keyboard command.

3. Calibration of the Isothermal Input Connector is complete.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Isothermal Input Connector is given in Table 175-3.

For parts ordering information, see Section 6 of this manual.

Figure 175-2 is a schematic diagram of the Isothermal Input Connector.

TABLE 175-3. ISOTHERMAL INPUT CONNECTOR
(SEE FIGURE 175-2.)

| REFERENCE DESIGNATOR A—>NUMERICS--->		S	----------DESCRIPTION---------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C	1		CAP.CER.0.22UF,-—20X,50V,25U	519157	51406	RPE111Z5U224M50V	1		
H	1		WASHER.LOCK.SPLIT,S STEEL,#4	147603	89536	147603	6		
H	2		SCREW.MACH.PHS.BR,6-32X1/4	615591	89536	615591	60		
H	3		STEEL.CAD.PLATED,.125X .500	276493	89536	276493	4		
H	4		SCREW.MACH.PHP.S.STL,4-40X1-7/16	403782	89536	403782	6		
H	5		WASHER.FLAT.STEEL,#4,0.030 THK	147728	89536	147728	4		
MP	1		BLOCK.ISOTHERMAL	579110	89536	579110	1		
MP	2		ISOTHERMAL.INSULATOR	579128	89536	579128	1		
MP	3		STANDOFF.BR.RD.SWGD,ANTI-ROT,6-32THRD	643148	89536	643148	60		
MP	4		CONNECTOR HOUSING, TOP	578971	89536	578971	1		
MP	5		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1		
MP	6		DECAL. ISOTHERMAL INPUT CONNECTOR	634584	89536	634584	1		
MP	7		DECAL. OPTION -175	634519	89536	634519	1		
MP	8		TAPE.FOAM.PVC.1/4W,3/8 THK	603134	89536	603134	2		
P	36, 37		CONN.PWB EDGE.REC.90,0.156 CTR,44 POS	614313	89536	614313	2	1	
Q	1	•	TRANSISTOR.SI.NPN.SELECTD.TEMP SENSOR	640862	89536	640862	1		
R	1		RES.VAR.CERM.50K,-—10X,0.5W	697300	89536	697300	1		
R	2		RES.MF,34.8K,-—1X,0.125W,25PPM	312181	89536	312181	1		
R	3, 4		MATCHED RES. SET ISOTHERMAL	617597	89536	617597	1		
R	8		RES.MF,100K,-—1X,0.125W,100PPM	248807	91637	CMF551003F	1		

MP6

MP4

MP7

MP5

2280A-175
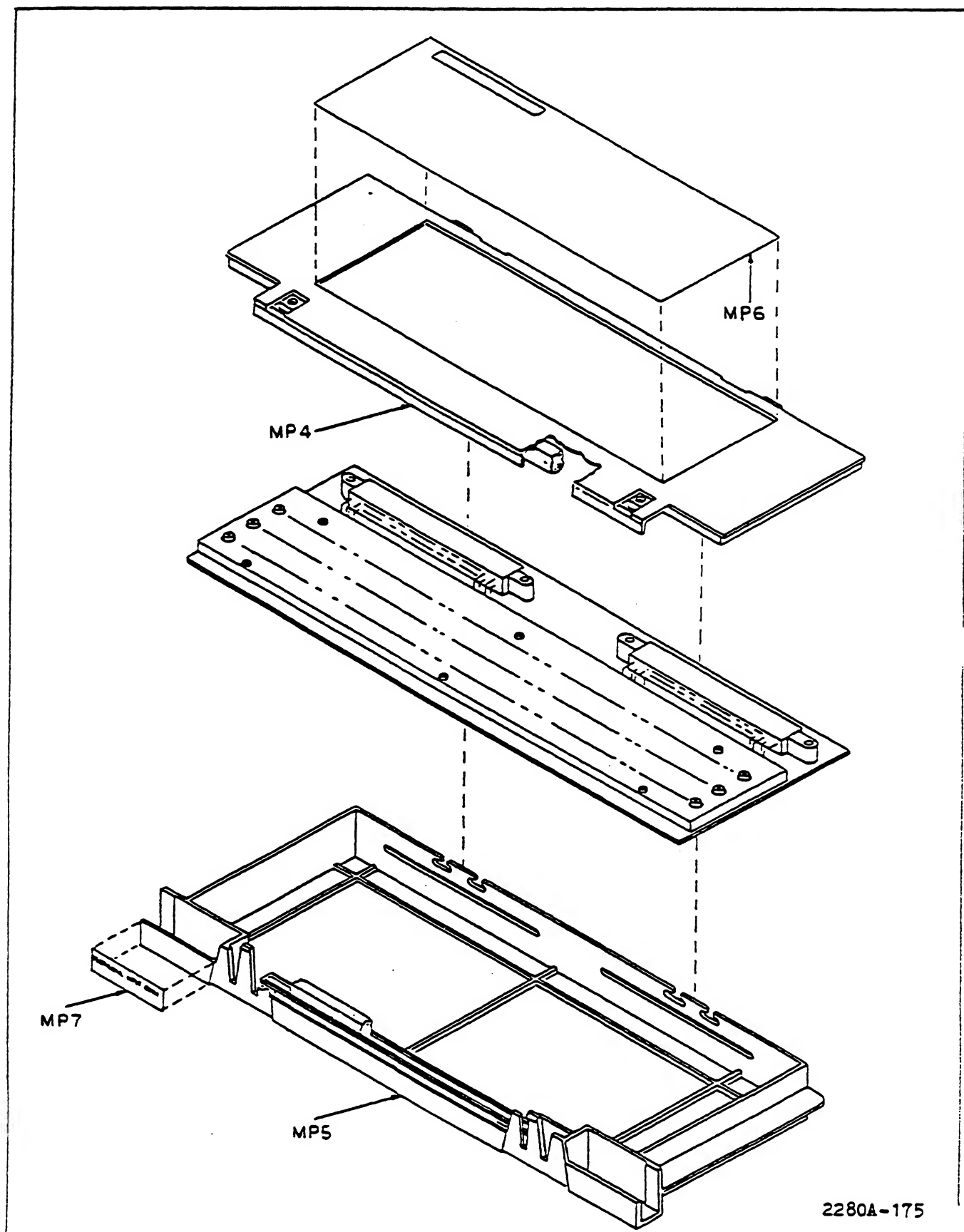
Figure 175-2. -175 Isothermal Input Connector

DESCRIPTION

The -176 Voltage Input Connector (shown in Figure 176-1) is a card-edge connector assembly that connects to the -162 Thermocouple/DC Volts Scanner and provides up to 20 channels of dc voltage input.

The entire connector assembly is enclosed in a plastic housing that provides protection for terminal connections and strain relief for external wiring. When installed, the housing attaches to the Front End chassis with retaining screws on each end.
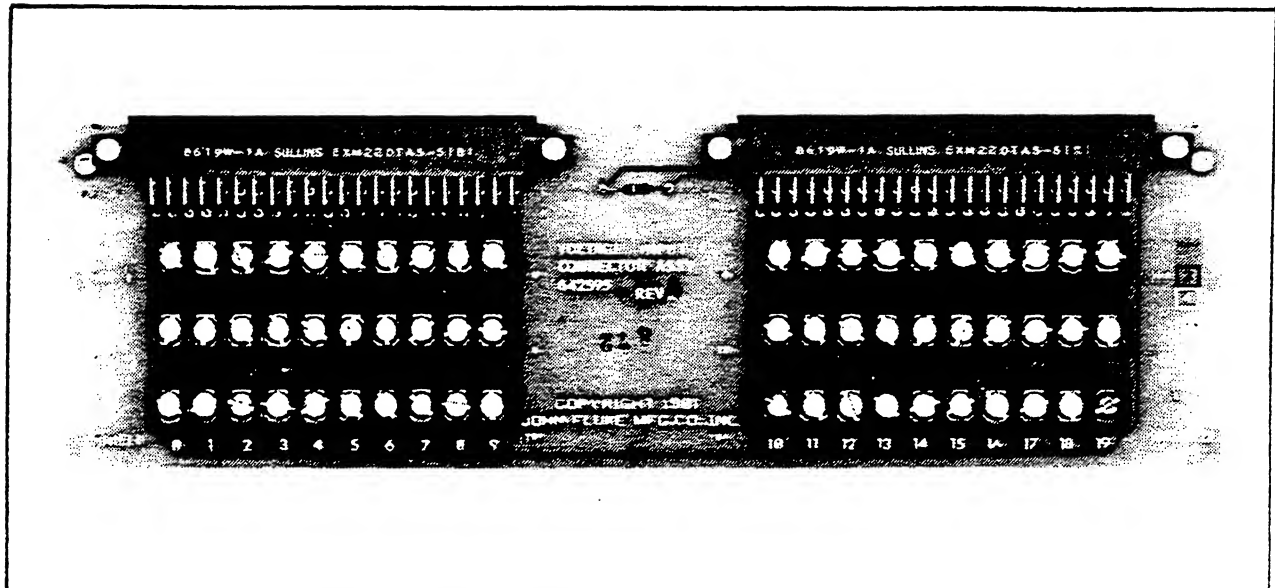

Figure 176-1. Voltage Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Voltage Input Connector theory of operation, performance tests, a parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are found in the Helios I System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 176-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

Table 176-1. Required Test Equipment for -176

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	+/- 31.3 mV +/- 20 uV +2.048V +/- 50 uV -2.048V +/- 2 uV of +2.048 500 mV +/- 20 uV 6.2V +/- 155 uV 6.8V +/- 0.1V 5.0V +/- 100 uV 7.9V +/- 200 uV *63V +/- 800 uV 1.008V, +/- 40 uV	Fluke 343
100:1 Divider	+/- 0.005%	Fluke Y2022
High Performance A/D Converter	NA	Fluke Option -161
Thermocouple/DC Volts Scanner	NA	Fluke Option -162
Voltage Input Connector	NA	Fluke Option -176

THEORY OF OPERATION

The Voltage Input Connector theory of operation includes a functional description and a detailed circuit description. The schematic diagram for the connector is located at the end of this subsection.

Functional Description

The Voltage Input Connector provides screw terminal inputs for external dc voltage sources. Received voltages are then routed to the Thermocouple/DC Volts Scanner.

---

* 63V output used for only one optional test.

Detailed Circuit Description

Up to 20 dc voltage sources can be attached to the Voltage Input Connector through HIGH, LOW and SHIELD terminals for each channel, with 250V rms spacing maintained between terminals.

The dc voltages across the high and low channel terminals are routed to the scanner through two card-edge connectors. The voltage inputs are then selected and conditioned by the Thermocouple/DC Volts Scanner for conversion by the A/D Converter.

GENERAL MAINTENANCE

The -176 Voltage Input Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the instructions in Section 4 of this manual.

PERFORMANCE TEST

The following performance test can be used to verify that the Voltage Input Connector is functioning properly. The performance test can also be used as an initial acceptance test.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE PROCEDURES IN THIS SECTION.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the address switch on the A/D Converter to 0 (refer to the A/D Converter subsection of the System Manual for switch setting instructions). Install the A/D Converter in the top option slot of the Front End, then install the -162 DC Volts/Thermocouple Scanner in the slot immediately below the A/D Converter.

3. Connect test leads to the HI and LO terminals for channel 0 on the input connector, then install the Voltage Input Connector on the Scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the calibrator output to the input of the 100:1 divider. Connect the divider output to the Voltage Input Connector test leads.

6. Set the calibrator output to 6.3000V dc (63 mV from the divider).

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..19)=DVIN,MAX=0.063 <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>
```

Verify that the value returned for the selected channel is between 6.29900E-02 and 6.30100E-02 (63 +/- 0.01 mV).

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
```

```
110    PRINT #1,"def chan(0..19)=dvin,max=0.063"
120    GOSUB 300
130    PRINT #1,"format=decimal"
140    GOSUB 300
150    REM make measurement and read in response
160    PRINT #1,"send chan(0..19)"
170    FOR I=0 TO 19
180    INPUT #1,M$
190    PRINT "chan";I;"=";
200    PRINT USING "###.##";VAL(M$)*1000;
210    PRINT " millivolts DC"
220    NEXT I
230    END
300    REM wait for message accepted promt
310    INPUT #1,A$
320    IF A$<>"!" THEN GOTO 310
330    RETURN
```

Program for 1722A:

```
10     CLOSE 1,2
20     PRINT CHR$(27);"[2J";
30     REM open communication port and empty Front End buffer
40     OPEN "KB1:"AS NEW FILE 1%
50     OPEN "KB1:"AS OLD FILE 2%
60     PRINT #1,CHR$(3);
70     REM set up Computer Front End
80     PRINT #1,"mode=comp"
90     GOSUB 300
100    PRINT #1,"count=off"
110    GOSUB 300
120    PRINT #1,"def chan(0..19)=dvin,max=0.063"
130    GOSUB 300
140    PRINT #1,"format=decimal"
150    GOSUB 300
160    REM make measurement and read in response
170    DIM M$(20)
180    PRINT #1,"send chan(0..19)"
190    FOR I%=0 TO 19\INPUT #2,M$(I%)\NEXT I%
200    X%=0\I%=0
210    FOR C%=0 TO 1
220    PRINT TAB(35*C%);"chan";I%;"=";
230    PRINT USING "S###.##",VAL(M$(X%))*1000;\PRINT" millivolts DC";
240    X%=X%+1\I%=I%+1\IF X%>19 THEN 270
250    NEXT C%
260    GOTO 210
270    END
300    REM wait for message accepted prompt
310    INPUT #2,A$
320    IF A$<>"!" THEN GOTO 310
330    RETURN
```

The value returned for the selected channel should be 63 +/- 0.01 mV.

8. Set the calibrator output to 0. Then move the test leads of the Voltage Input Connector test to the terminals for the next channel to be tested.

9. Repeat steps 6 through 8 for each remaining voltage input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

10. The Voltage Input Connector performance test is now complete.

CALIBRATION
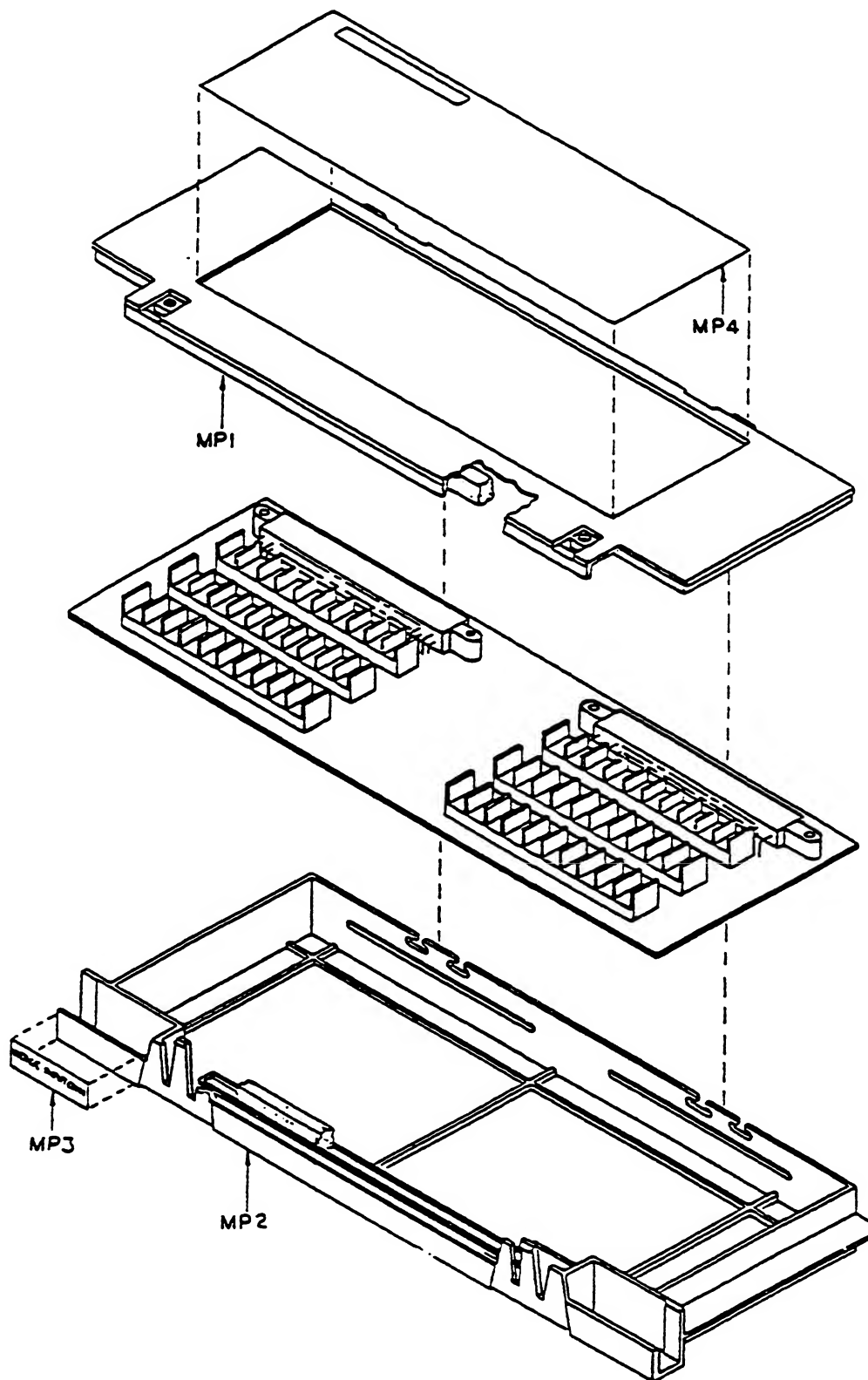
The Voltage Input Connector requires no calibration.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Voltage Input Connector is given in Table 176-2.

For parts ordering information, see Section 6 of this manual.

Figure 176-2 is a schematic diagram of the Voltage Input Connector.

TABLE 176-2.
(SEE FIGURE 176-2.) ... TAPE, INPUT CONNECTOR PCA

REFERENCE DESIGNATOR A->NUMERICS--->		S ----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
H	1	STEEL.CAD.PLATED,.125X .500						
H	2	WASHER.FLAT.STEEL,#4,0.030 THK	276493	89536	276493			
MP	1	CONNECTOR HOUSING, TOP	147728	89536	147728	4		
MP	2	CONNECTOR HOUSING, BOTTOM	578971	89536	578971	4		
MP	3	DECAL. OPTION -176	656876	89536	656876	1		
MP	4	DECAL, VOLTAGE INPUT CONNECTOR	634527	89536	634527	1		
MP	5	TAPE,FOAM,PVC,1/4W,3/8 THK	634592	89536	634592	1		
P	36, 37	CONN.PWR EDGE.REC.90,0.156 CTR,44 POS	603134	89536	603134	1		
R	1	RES.CF.3.9K,+-5%,0.25W	614313	89536	614313	2		
TB	1- 6	SINGLE ROW, .325 CENTERS, 10 POSITION	342600	80631	CR251-4-SP3K9	2		
			615328	89536	615328	1		
						6		

Figure 176-2. -176 Voltage Input Connector

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DESCRIPTION

The -177 RTD/Resistance Connector (shown in Figure 177-1) mounts on the rear of the -163 RTD/Resistance Scanner and provides 20 sets of input screw terminals for connection to RTDs and resistances.

The -177 connector assembly is enclosed in a plastic housing that provides protection for terminal connections and strain relief for external wiring. Retaining screws at each end of the housing fasten the assembly to the Front End chassis.
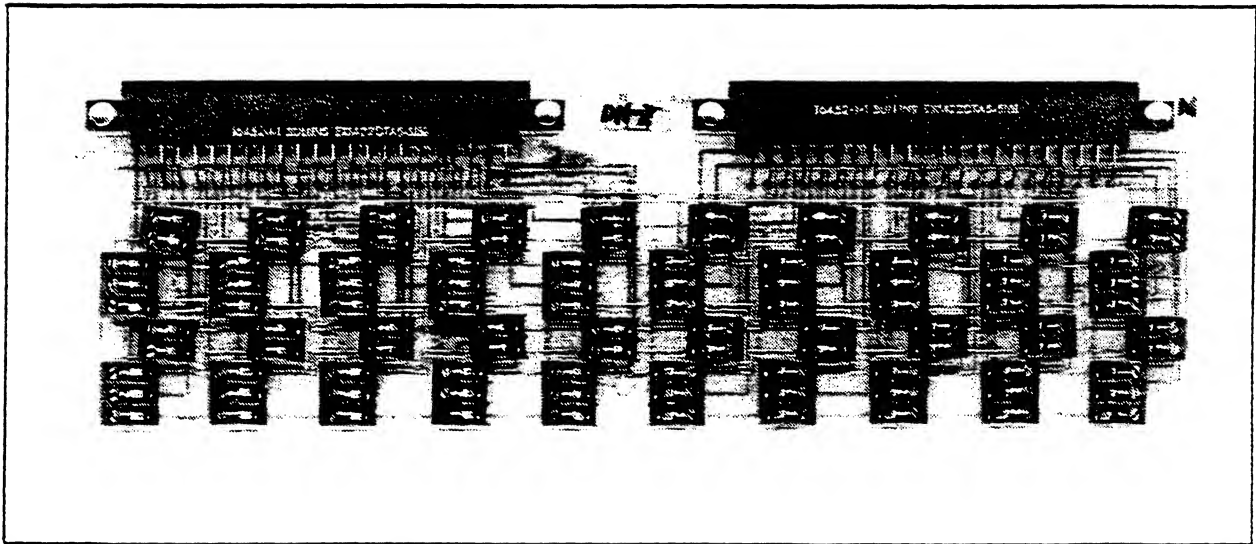

Figure 177-1. RTD/Resistance Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: RTD/Resistance Input Connector theory of operation, performance test information, replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are located in the Helios I System Manual.

THEORY OF OPERATION

The RTD/Resistance Input Connector theory of operation includes an overall level functional description and a detailed circuit description. The schematic diagram for the Input Connector is located at the end of this subsection.

Overall Functional Description

The RTD/Resistance Input Connector provides screw terminal inputs for connection to external resistances. These resistances are passed through two connectors to the -163 RTD/Resistance Scanner for conditioning.

Detailed Circuit Description

Twenty RTDs or other resistance sensors can be attached to the connector using five terminals per channel: HI EXC, HI, LO, LO EXC, and LO COM. Four terminals per channel are isolated from the other channels, providing for three 4-wire and one 3-wire mode of operation. The fifth terminal on each channel, LO COM, is a common return for either channels 0 through 9 or 10 through 19, providing for accuracy in 3-wire mode of operation. The 44-pin edge connectors provide paths through which the RTD/Resistance Scanner can select, excite, and measure resistances wired to the connector terminals.

GENERAL MAINTENANCE

The -177 RTD/Resistance Input Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on the surface. If cleaning is necessary, refer to the cleaning instructions in Section 4 of this manual.

PERFORMANCE TEST

There is no separate performance test procedure for the -177 RTD/Resistance Input Connector.

The -177 connector is tested along with the -163 RTD/Resistance Scanner. Refer to the -163 RTD/Resistance Scanner subsection of Section 8.

CALIBRATION

The RTD/Resistance Input Connector does not require calibration.

## LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the RTD/Resistance Input Connector is given in Table 177-1.

For parts ordering information, see Section 6 of this manual.

Figure 177-2 is a schematic diagram of the RTD/Resistance Input Connector.

TABLE 177-1. -177 RTD/RESISTANCE INPUT CONNECTOR
(SEE FIGURE 177-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
H	1	STEEL,CAD,PLATED,,125X .500	276493	89536	276493	4		
H	2	WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4		
MP	1	CONNECTOR HOUSING, TOP	578971	89536	578971	1		
MP	2	CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1		
MP	3	DECAL,RTD/OHMS INPUT CONN.	748038	89536	748038	1		
MP	4	DECAL, OPTION -177	748020	89536	748020	1		
MP	5	TAPE,FOAM,PVC,1/4W,3/8 THK	603134	89536	603134	2		
P	39, 40	CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2		
TB	1- 10, 21-	TERM STRIP,PWB,ANGL ENTRY,2 CONTACTS	478867	89536	478867	20		.
TB	30		478867					
TB	11- 20, 31-	TERM STRIP,PWB,ANGL ENTRY,3 CONTACTS	474221	89536	474221	20		
TB	40		474221					

MP3

MP1

MP4

MP2
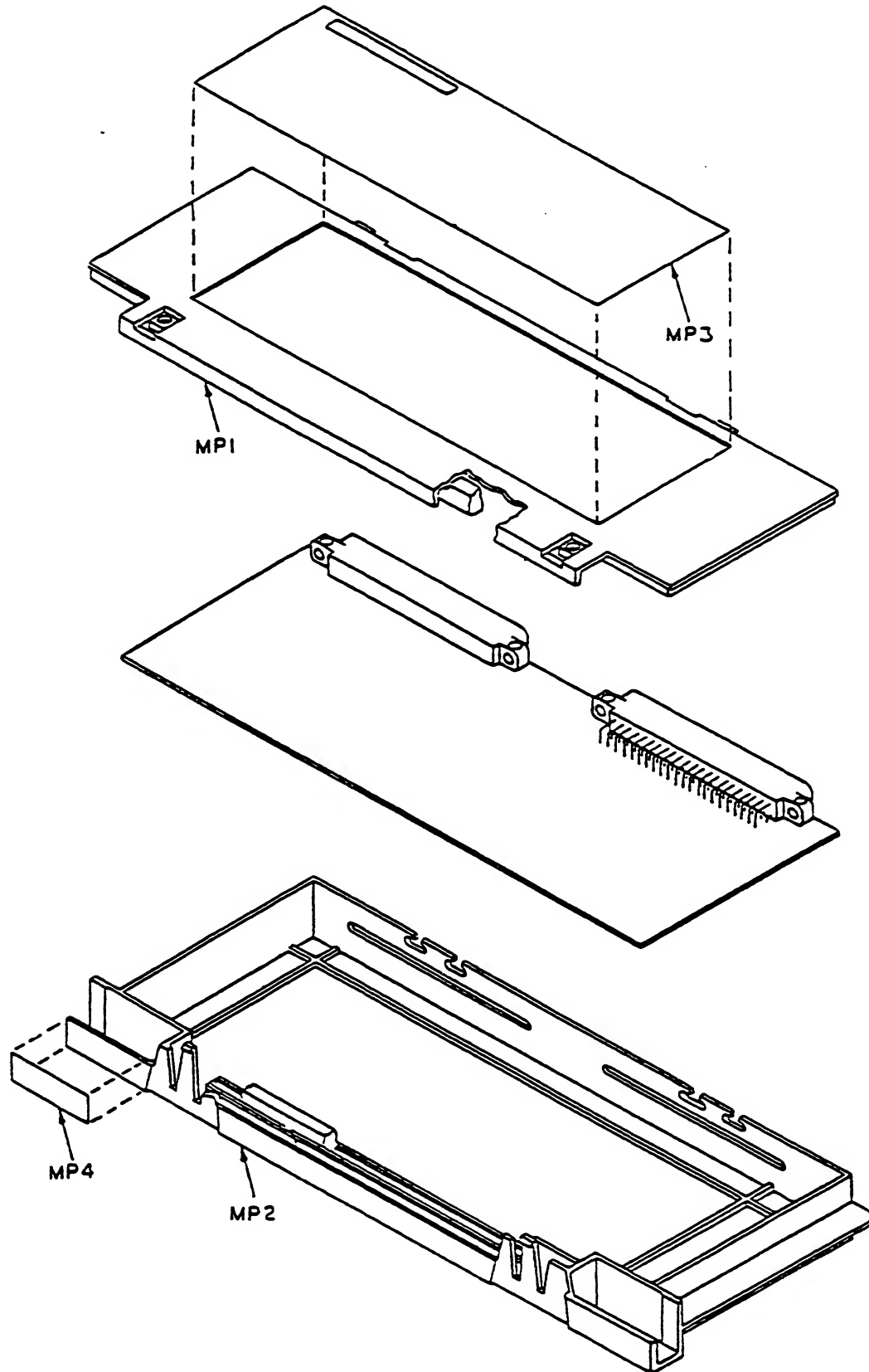
2280B-177

Figure 177-2. -177 RTD/Resistance Input Connector

DESCRIPTION

The -179 Digital/Status Input Connector (shown in Figure 179-1) connects to the -168 Digital I/O Assembly, providing screw-terminal connections that allow the input of BCD digital data, binary digital data, or status input information to the Front End.
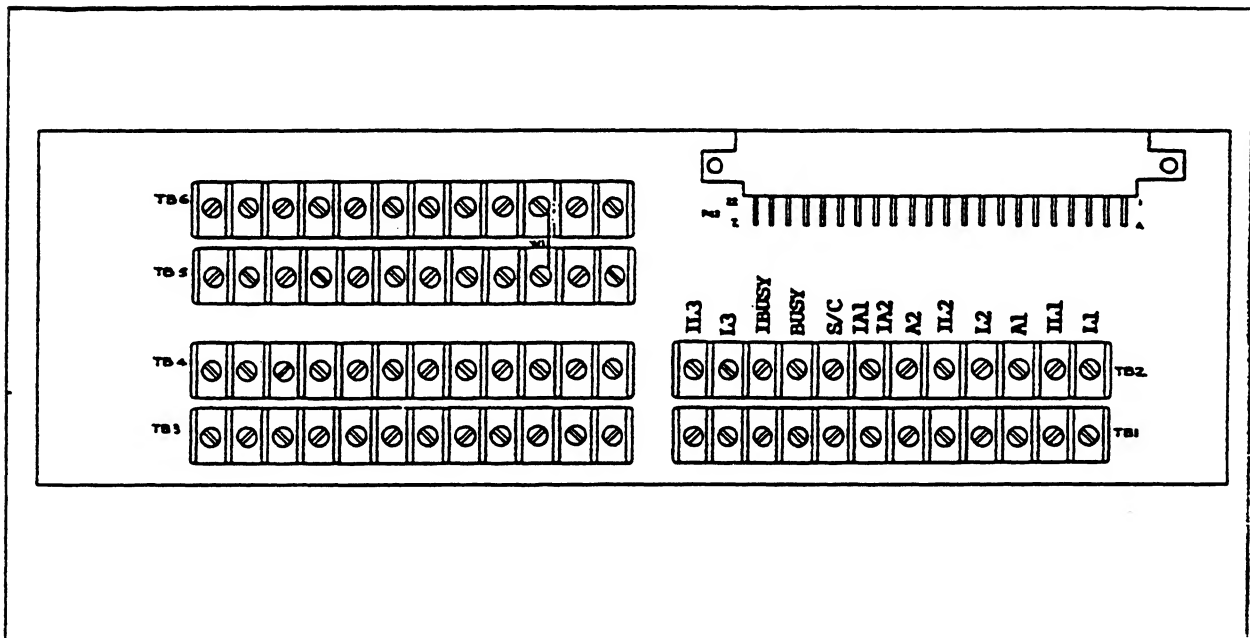

Figure 179-1. Digital/Status Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Digital/Status Input Connector theory of operation, performance testing information, a replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are found in the Helios I System Manual.

Option specifications are found in an appendix of this manual and in the System Manual.

THEORY OF OPERATION

The Digital/Status Input Connector provides a path from screw terminals on the connector body to the card-edge connector pins on the Digital I/O Board. There is no circuitry on the Digital/Status Input Connector PCA other than printed traces. Instructions for configuring the connector are given in the Helios I Computer Front End System Manual.

When configured for status input, the Digital/Status Input Connector allows the -168 Digital I/O Assembly to accept a maximum of 20 separate one-bit inputs from an external source for each Digital I/O assembly installed in the Front End Mainframe or a 2281A Extender Chassis. Each bit is associated with a channel programmed as status input.

When configured for digital input, the Digital/Status Input Connector allows the Digital I/O Assembly to accept 20 bits of parallel digital data from an external source. This data is received at the channel address set on the associated Digital I/O Board.

GENERAL MAINTENANCE

The -179 Digital/Status Input Connector normally does not require cleaning, unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

There is no separate performance test for the -179 Digital/Status Input Connector. The -179 connector is tested during input mode performance testing of the -168 Digital I/O Assembly performance test. Refer to the -168 Digital I/O assembly subsection of section 8.

CALIBRATION

There are no calibration adjustments for the Digital/Status Input Connector.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

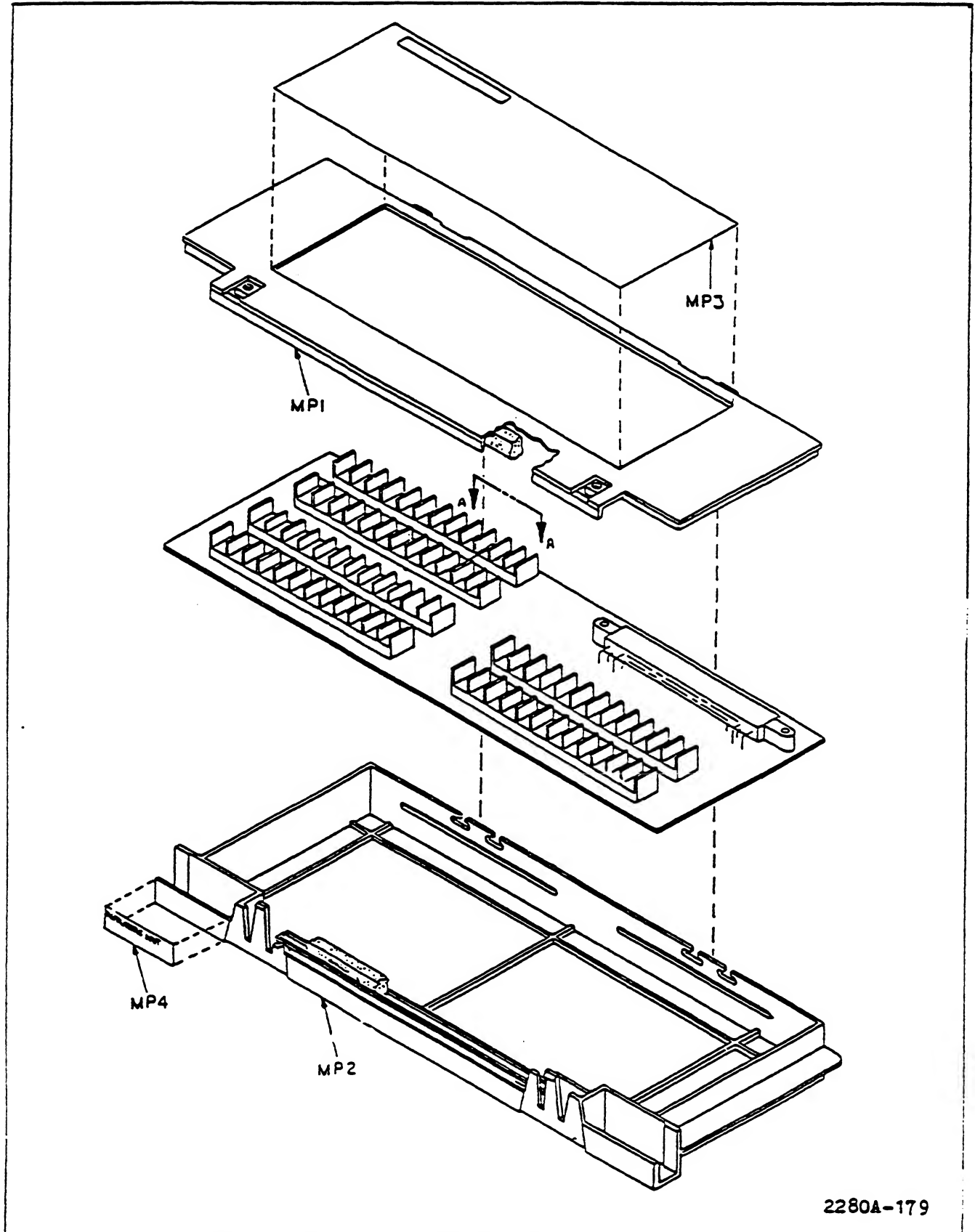An illustrated parts list for the Digital/Status Input Connector is given in Table 179-1.

For parts ordering information, see Section 6 of this manual.

Figure 179-2 is a schematic diagram of the Digital Status Input Connector.

TABLE 179-1. -179 DIGITAL/STATUS INPUT CONNECTOR
(SEE FIGURE 179-2.)

REFERENCE DESIGNATOR A->NUMERICS---)		S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
H	1		STEEL.CAD.PLATED..125X .500	276493	89536	276493	2		
H	2		WASHER.FLAT.STEEL.#4.0.030 THK	147728	89536	147728	2		
MP	1		CONNECTOR HOUSING, TOP	578971	89536	578971	1		
MP	2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1		
MP	3		DECAL.DIGITAL/STATUS INPUT CONN.	634626	89536	634626	1		
MP	4		DECAL, OPTION -179	634550	89536	634550	1		
MP	5		TAPE.FOAM.PVC.1/4W.3/8 THK	603134	89536	603134	2		
P	43		CONN.PWB EDGE.REC.90.0.156 CTR.44 POS	614313	89536	614313	1		
TB	1- 6		SINGLE ROW, .325 CENTERS, 12 POSITION	615690	89536	615690	6		

MP3

MP1

A

A

MP4

MP2

2280A-179

Figure 179-2. -179 Digital/Status Input Connector

CONTENTS

INTRODUCTION

The Scan/Alarm option (-201) provides a variety of additional functions useful for alarm and monitoring applications. A description of these functions is listed below.

o   Automatic Scanning of Input Channels.

The Scan/Alarm option provides a mechanism for measuring the input channels on a regular time interval without intervention from the host. Up to four different Scan Groups can be established, each measuring the inputs with their own independent time interval. Channels 0 through 999 are available.

o   Limit Checking

Each channel can have up to four alarm limits associated with it. These alarm limits, two high alarms and two low alarms, permit Helios I to be used as a high accuracy monitoring system without the intervention of the host computer.

o   Data Buffering

Up to four data buffers may be specified to hold measurement data while the host computer is busy with higher priority tasks. While the amount of available data storage depends on the size of the system involved, most systems are able to store up to 20,000 readings. The data is stored with a time stamp and status, and the oldest reading is read from the buffer first.

o   Polynomial Linearizations

Frequently, measurements requiring linearizations are made to convert the raw data to engineering units. The Scan/Alarm option provides a second order polynomial linearization function for this purpose. This frees up the host computer for more important tasks.

o   Alarm Outputs

Status outputs may be directly coupled to alarm conditions. In the event a hazardous condition is detected, this provides a means for corrective action without the intervention of the host computer.

o   Alarm Annunciation

To facilitate monitoring applications, an alarm annunciator is included in the Scan/Alarm option. This feature provides all the drive signals necessary to implement the flashing light and audible alarm indications common to these applications.

o   Communication Monitoring

In the event the host computer does not communicate with Helios I
for a user-specified period of time, all alarm data is logged
directly on the local printer. This will continue until the host
re-establishes communications with Helios I.

o   Local Printout

The Scan/Alarm option permits the measured data to be logged
directly on a local printer without the intervention of the host
computer. This is useful when the host computer is not available or
is not located at the measurement site.

o   Host Interrupt on Alarm

The Scan/Alarm option allows Helios I to initiate communications
with the host if an alarm condition has occurred. This feature
allows a monitor system to "report on exception" basis only and
reduces the amount of communications required by the host computer.

SUPPORT PANEL FEATURES

The Scan/Alarm option replaces the standard Helios I Computer Interface
Assembly. Therefore, the view from the rear of the Helios I shows the
following additional features on the support panel:

o   The PRINTER port provides a 25-pin serial (RS-232-C) printer
connection. Refer to "Connecting to the Printer Port" in Section 3A
of the Helios I System Manual for printer connection and setup
information.

o   The Alarm Output terminal block provides for external visual and
audible alarm connections, along with terminals for external alarm
acknowledgement. Related installation and usage instructions are
presented in Section 3B of the System Manual, under "-201,
Scan/Alarm Option."

WHERE TO FIND MORE INFORMATION

Specifications for the Scan/Alarm option are presented in Appendix 10A
of this manual. The Helios I System Manual discusses Scan/Alarm Option
installation procedures (Section 3B) and operating commands (Section 5).

THEORY OF OPERATION

The Helios Computer Front End with Scan/Alarm option uses most of the same circuitry as the standard Front End documented in Section 3 of this manual. However, the Helios Scan/Alarm option uses a non-standard Computer Interface Assembly. Additional features found on the Computer Interface Assembly used for the Scan/Alarm option include alarm annunciator control and output circuits and a slightly different memory allocation scheme.

Theory of operation for the Computer Interface Assembly used with the Scan/Alarm option is presented in the following paragraphs. Refer to Section 3 for all other mainframe theory of operation.

Figure 9A-1 is a functional block diagram of the Computer Interface Assembly. This assembly can be thought of as consisting of 17 functional circuit blocks.

The discussion of the Computer Interface assembly begins with a functional description of the assembly as a whole, followed by a more specific discussion of each of the 17 functional blocks.

The CPU, which controls operations on the Computer Interface Assembly, is a TMS-9995 microprocessor. The TMS-9995 interfaces with ROM and RAM in the conventional manner and with various I/O devices through a communications register unit (CRU) and the address lines.

At power-up, the reset circuit initializes various circuit elements and keeps the CPU from operating until the supply voltage is within operational limits. When reset is released, the CPU begins execution as directed by the ROM.

The CPU initializes the system based on: 1) configuration switch settings, 2) data that remains in the non-volatile RAM during the power-down state, and 3) information about serial link devices that are detected through the serial link communication interface.

After initialization is complete, the host communication interface is ready to accept commands from the host and pass them on to the CPU for interpretation and execution. Commands from the host can result in placing data into RAM, reading and returning data from RAM, setting or reading the clock data, or performing a measurement or control function on a serial link device.

A description of each of the 17 functional blocks that make-up the Computer Interface Assembly follows.

Power ON/OFF Reset Circuit

The power ON/OFF reset circuit monitors the +5V power supply and asserts RESET(L) when the voltage is below 4.6V. U16 is powered from the +5B supply, which is backed up by battery if the power is OFF. This allows RESET(L) to be actively asserted when power is OFF, and it is used by the memory chip selector block to ensure that the RAM's are de-selected while the power is below 4.6V.

R24 and R26 form a precision voltage divider off the +5V supply. The output of the voltage divider is compared by U16 (a dual-voltage comparator) to 1.23V, which is produced by R27 and VR2 (a band-gap reference diode). On power-up, when the +5V supply has reached 4.6V, U16 removes the common on pin 1 and lets C14 begin to charge through R28 to the +5V supply. When the voltage across C14 reaches 1.23V, U16 removes the common on pin 7, and RESET(L) is pulled to the +5V supply through R25. The time constant of C14 and R28 is short enough to ensure that the output pin 7 of U16 transitions without bounces and long enough to filter any bouncing that might occur when the first stage of U16 transitions.

Test Circuit

Part of U9 and U8 is used to form an R/S flip-flop, which can be used to stop and start CPU instruction execution.

The CPU is stopped by momentarily applying a low to pin 3 of J74, and it is started again by momentarily applying a low to pin 1 of J74.

Central Processor Unit (CPU)

The CPU is implemented by U20, a TMS-9995 16-bit microprocessor. The TMS-9995 onboard clock generator uses Y1, an 11.9808 MHz crystal, to determine the frequency of the clock. C18 and C19 are used to ensure proper capacitive loading for the onboard amplifiers.

Pull-up resistor, R32, de-asserts the HOLD(L) input on the TMS-9995 since this feature is not implemented.

Pull-up resistor, R33, asserts the READY input on the TMS-9995. When RESET(L) makes a low-to-high transition at power-on with READY asserted, the automatic first wait state generation feature of the TMS-9995 is selected. This causes one wait state to be added to every memory access cycle.

Data and Address Buffers

The 8-bit data bus is buffered by U30, an octal bus transceiver. The direction of data transfer is determined by the CPU control signal DBIN(L). This buffer, which is required due to the large number of memory ICs used in the Front End, is enabled only when DBIN(L) and MEMEN(L) are asserted.

The 16-bit address bus is buffered by octal buffers U21 and U31. These buffers are required due to the large number of memory ICs and CRU devices used in the Front End.

CPU Control Buffers and Logic

The CPU control signals MEMEN(L), WE(L)/CRUCLK(L), DBIN(L), and CLKOUT are buffered by U29, an octal buffer. This buffer is required due to the large number of memory ICs and CRU devices used in the Front End.

A buffered MEMEN(L) from U29, pin 9 is used on U30, pin 19 to enable the data bus buffer.

One of the inverters of U8 is used to generate the complement of WE(L)/CRUCLK(L) as required by some of the CRU devices.

Communication Register Unit (CRU) Device Selector Circuit

Figure 9A-2 shows a schematic diagram of the CRU device selector circuit. This circuit detects a CRU device input or output cycle by the CPU and selects the device based on the address bits A6 through A8.

When the data bits D5 through D7 are low and the control signal MEMEN(L) is high, U28, pin 15 is low. Since the enable inputs on U22, pins 4, 5, and 6 are all asserted, the U22 output corresponding to the address bits A6 through A8 are low. When the CRUCLK(L) control signal is low, all the enable inputs on U25, pins 4, 5, and 6 are asserted and the output corresponding to the address bits A6 through A8 are low. In other words, when the CPU is requesting communication with a CRU device, one output of U22 is low and one output of U25 follows CRUCLK(L).

Table 9A-1 shows the base address, the CRU device that is selected, and the type of transaction.

Of the four ports that can be selected, the Front End uses only the host, printer, and serial link ports.

The CRU device selector circuit can select multiple CRUs simultaneously. However, pins 10 and 11 on U22 enable CRU devices that are for input only, and pins 10 and 11 on U25 enable CRU devices that are for output only. When an output device is receiving data from the CPU and the CRUCLK(L) signal is toggling, the input-only device of the same address that is enabled by U22 is inactive since DBIN(L) is high. When an input device is sending data to the CPU, the CRUCLK(L) signal is high and none of the outputs of U25 are asserted.
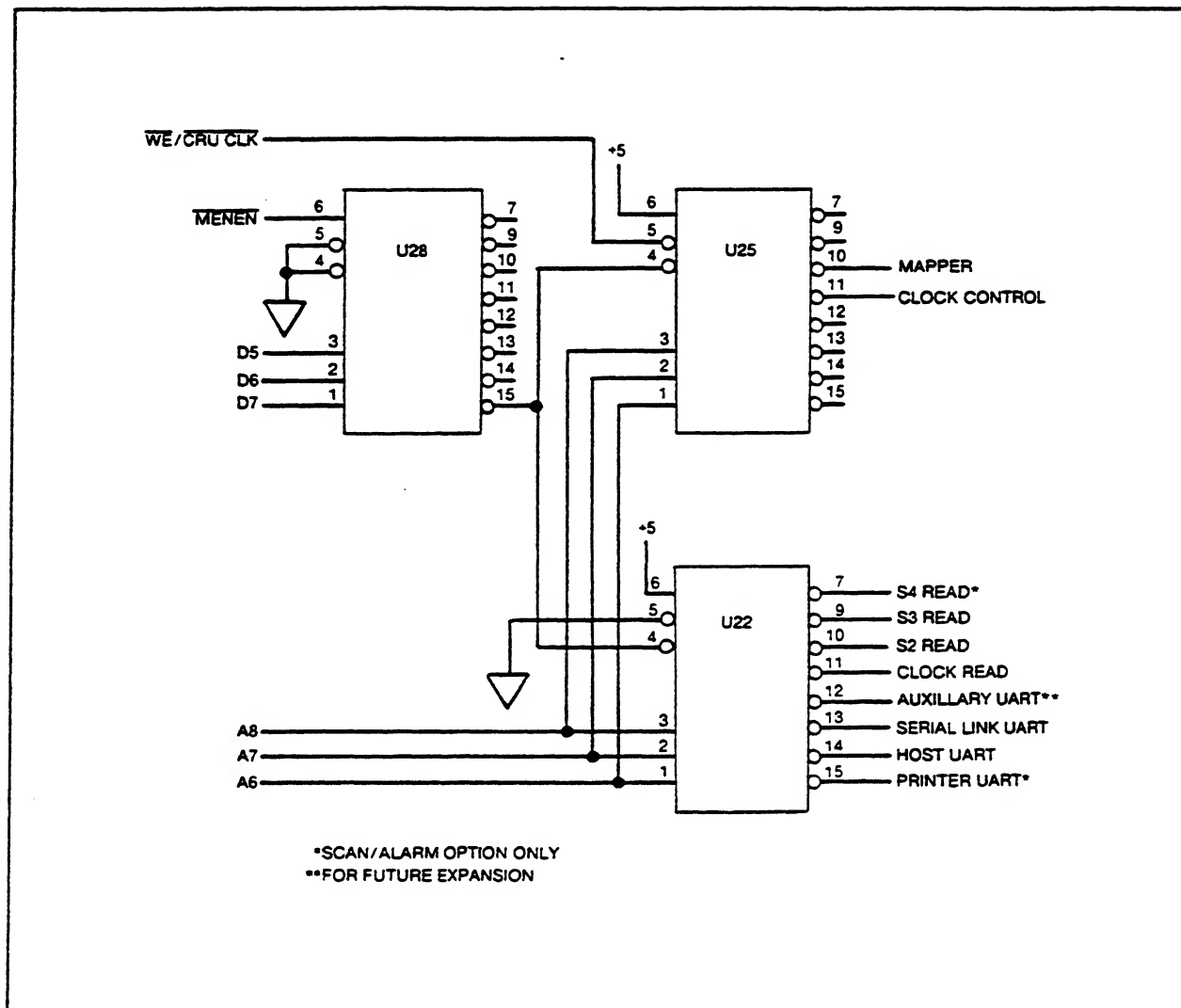
Figure 9A-2. CRU Device Selector Circuit

Table 9A-1. CRU Device Selection

ADDRESS	INPUT	OUTPUT
0x0000	Printer Port	Printer Port
0x0040	Host Port	Host Port
0x0080	Serial Link	Serial Link
0x00C0	Auxiliary Port	Auxiliary Port
0x0100	Clock & Misc	Clock & Alarm
0x0140	Switch 2	Mapper & Misc
0x0180	Switch 3	Host Port
0x01C0	Switch 4	Printer Port

Memory Chip Selector Circuit

The memory chip selector circuit decodes the address bus and other inputs from the CPU via a CRU device to select one of 16 memory ICs for data transfer.

The CPU has the ability to address directly 64K bytes of memory with the 16-bit address bus. This address space contains EPROM (Erasable Programmable Read-Only Memory) and RAM (Random-Access Memory). Since the Scan Alarm requires more memory than can be accommodated by the 64K-byte address space, part of the memory is multiplied by using banks and pages. Banks denote selection between memory devices, and pages denote selection within a single memory device. Figure 9A-3 shows how the memory is organized.

U32, a 3-to-8 line decoder/multiplexer, asserts the output that corresponds to address bits A13 through A15 when the CPU control signal MEMEN(L) is asserted low.

Table 9A-2 shows the relationship between the address bits and the chip that is selected.
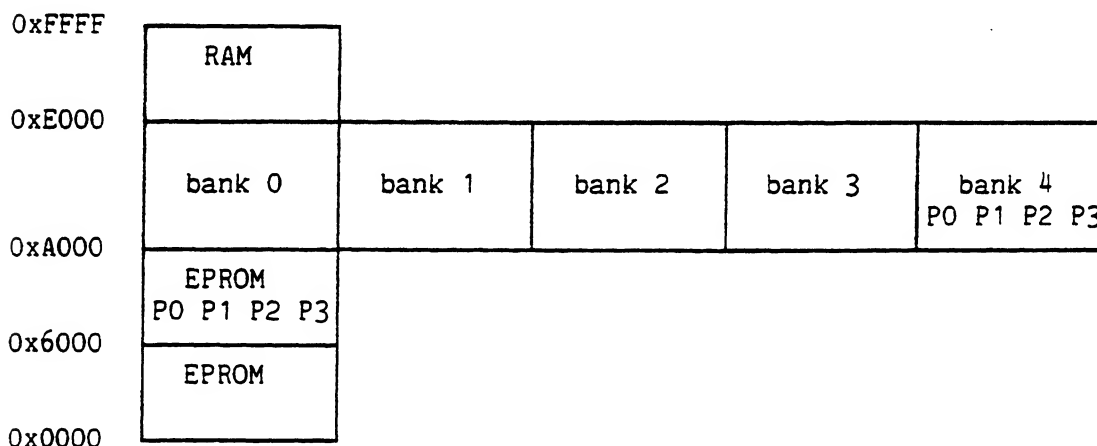
Figure 9A-3. Memory Organization

Table 9A-2 Address Bits and Chip Selection

ADDRESS RANGE	U32 PIN ASSERTED	CHIP SELECTED
0x0000-0x1FFF	15	U46 (EPROM)
0x2000-0x3FFF	14	U49 (EPROM)
0x4000-0x5FFF	13	U45 (EPROM)
0x6000-0x7FFF	12	U48 (EPROM)
0x8000-0x9FFF	11	U44 (EPROM)
0xA000-0xBFFF	10	U27 (Bank selector)
0xC000-0xDFFF	9	U24 (Bank selector)
0xE000-0xFFFF	7	U47 (RAM)

When selected by U32, the 3-to-8 line decoder/multiplexers, U24 or U27 asserts the output that corresponds to the signals on the input pins 1, 2, and 3. These inputs are supplied as signals MM0 through MM2 from U26, an 8-bit addressable latch, which is used as a CRU output device. The CPU selects the proper bank for the data transaction and sets the bits into the appropriate outputs of U26 prior to accessing the RAM.

Table 9A-3 shows the relationship between the mapper bits MM0 through MM2 and the RAM chip that is selected.

			Table 9A-3. Mapper Bits and RAM Chip Selection		
MM2	MM1	MM0	U24 OR U27 PIN ASSERTED	RAM SELECTED IF U24 ENABLED	RAM SELECTED IF U27 ENABLED
0	0	0	15	U36	U38
0	0	1	14	U41	U43
0	1	0	13	U35	U37
0	1	1	12	U40	U42
1	0	0	11	U39	U34

U24 and U27 are CMOS ICs and have power applied from the +5B supply when Front End power is OFF. The enable input on pin 6 of U24 and U27 is connected to the power ON/OFF reset circuit. When the +5V supply is below 4.6V, the RESET(L) signal is asserted low, which de-selects U24 and U27, which in turn de-select all the banked RAMs. This ensures non-volatile memory retention of parameters and data. The inputs of U24 and U27 are pulled to the +5V supply by resistors in network Z6, since the drive signals originate from TTL-LS ICs.

Outputs on U26, pins 11 and 12 are used to provide inputs from the CPU to the host communication interface circuitry. The output on U26, pin 10 is used to reset the alarm annunciator card.

The CPU sets the outputs of U26 with a CRU output cycle. The RESET(L) signal asserted at power up on U26, pin 15 (CLEAR) causes all outputs to be set low. The address of the latch to be written to is from address bits A1 through A3, and the state of the latch is defined by address bit A0. The CRU device selector circuit supplies the enable input on U26, pin 14 as discussed above.

Read-Only Memory (ROM)

The Read-Only Memory that supplies the firmware for the CPU consists of three 8K-byte by 8-bit EPROMs (U45, U46, and U49) and two 32K-byte by 8-bit EPROMS (U44 and U48).

The data in these EPROMs is retrieved by a CPU read cycle. Address bits A0 through A12 are decoded by each EPROM to determine the byte being fetched. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 to provide the chip-select signal to pin 20 on one of the five EPROMs. In addition, signals A and B from U18, pins 4 and 5 are used to select the appropriate page within memory chips U44 and U48. This selection is made prior to accessing the memory devices with a read cycle. The selected EPROM outputs data to the data bus when OE(L) is asserted low; OE(L) is the same as DBIN(L).

Capacitors C29, C30, C31, C38, and C39 are power supply bypass capacitors that reduce noise coupling through the power distribution circuit.

Wire jumpers W1, W2, W3, W5, and W6 are hardwired on the Computer Interface PCA as shown on the schematic diagram. These jumpers are provided for future modification and can be ignored.

Jumper W10 and W11 must be connected to signals B and A, respectively (as shown on the schematic diagram).

Random-Access Memory (RAM)

The Random-Access Memory used by the CPU consists of nine 8K-byte by 8-bit CMOS static RAMs (U35 through U38, U40 through U43 and U47) and two 32K-byte by 8-bit CMOS static RAMs (U34 and U39).

These RAMs are powered by the +5B (battery backed up) power supply so that the data is non-volatile when the power is OFF. The power ON/OFF reset circuit and the memory selector circuit ensure that the chip select input pin 20 is de-asserted high when the +5V supply is below 4.6V.

Data is written into these RAMs by a CPU write cycle. Address bits A0 through A12 are decoded by each RAM to determine the byte being written to. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 and the memory mapper, U26, bits MM0 through MM2 to provide the chip select signal to pin 20 on one of the nine RAMs. In addition, MM3 and MM4 are used to select one of four 8K-byte pages within U34 and U39. This selection, like the bank selection, must be made prior to the memory access cycle. The data on the data bus is written into the selected byte of the selected RAM when WE(L) is asserted low.

The data in these RAMs is retrieved by a CPU read cycle. Address bits A0 through A12 are decoded by each RAM to determine the byte being fetched. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 and the memory mapper, U26, bits MM0 through MM2 to provide the chip select signal to pin 20 on one of the nine RAMs. The selected RAM outputs data to the data bus when OE(L) is asserted low: OE(L) is the same as DBIN(L).

Capacitors C21, C22, C23, C25, C27, C32, and C33 through C37 are power supply bypass capacitors that reduce noise coupling through the power distribution circuit.

Wire jumper W7 must be connected to MM4. Wire jumper W4 on the Computer Interface PCA is as shown on the schematic diagram. This jumper is provided for future modification and can be ignored.

Configuration Switches and Interface Circuit

The circuit block containing the configuration switches and interface circuit consists of CRU devices and DIP switches for the input of configuration information to the CPU. There are three identical circuits in this block and each operates the same; however the data obtained is for different use by the CPU. Switch pack S2, pull-up resistor network Z1, and data selector/multiplexer U15 are used to provide information about the host computer communication port. Switch pack S3, pull-up resister network Z2, and data selector/multiplexer U23 are used to provide information about the host computer protocol and local line frequency. Switch pack S4, pull-up resistor network Z3, and data selector/multiplexer U33 are used to provide information about the printer communication port.

When the CRU device selector circuit detects that the CPU is accessing this circuit, the appropriate output of U22 asserts the strobe input, pin 7, of the data selector/multiplexer U15, U23, or U33. Address bits A1 through A3 are used to address each switch that is connected with a pull-up resistor to each input of U15, U23, or U33.

If the selected switch is closed, a low is output on pin 5 of the enabled data selector/multiplexer. If the selected switch is open, a high is output on pin 5 of the enabled data selector/multiplexer. These pin 5 outputs are the CRUIN signal for the CPU and are input while DBIN(L) is asserted low.

The function of each switch is shown on the decal located on the rear bezel of the Front End.

This circuit is only used at power-up. Therefore, if the configuration is changed, the power to the Front End must be cycled for the CPU to be reconfigured.

Clock and Clock Interface Circuit

The clock and clock interface circuit provides the Front End with a non-volatile system clock and calendar. U19 is a CMOS calendar/clock IC that is powered from the +5B (battery backed up) power supply. Interface to the CPU is provided by CRU devices for control and reading of the clock.

The CRU device that allows the CPU to output control signals and data to U19, is U18, an 8-bit addressable latch. The CPU sets the outputs of U18 with a CRU output cycle. The RESET(L) signal asserted at power-up on U18, pin 15 (CLEAR) causes all outputs to be set low. The address of the latch to be written to is from address bits A1 through A3 and the state of the latch is defined by address bit A0. The CRU device selector circuit supplies the enable input on U18, pin 14 as discussed above.

When the CRU device selector circuit detects that the CPU is accessing this circuit to read data, the output of U22, pin 11 is asserted low and provides the strobe input, pin 7 of U17, a data selector/multiplexer.

Table 9A-4 defines the signals used for control and setting of U19.

Table 9A-4. U19 Control Signals

CRU ADDRESS	U18 PIN	U19 PIN	SIGNAL
0x0100	4	3	Address 0
0x0101	5	2	Address 1
0x0102	6	1	Address 2
0x0103	7	5	Device Select
0x0104	9	4	Command Strobe
0x0105	10	8	Shift Clock
0x0106	11	6	Clock Data Input
0x0107	12		Alarm Signal

The control inputs on U19 are set by the CPU through U18 so that a bit of data from the clock is present on U19, pin 9 that is input to the CPU via U17, pin 4 by a CRU input cycle that addresses this input.

U17 is also used to input data from the communication interface circuit blocks.

Clock frequency is controlled by Y2, a 32.768 kHz crystal. Capacitors C15 and C16 are required to maintain oscillator operation and stability. Resistor R31 is a pull-up resistor for the clock data output on U19, pin 9, since this output is open drain.

Host Communication Circuit

The host communication circuit provides the interface between the CPU and the serial, asynchronous, communication channel with the host computer. The line driver and receiver portion of the circuit can be switch selected to EIA voltage levels with RS-232-C protocol or RS-422 differential voltage levels.

Data exchange with the CPU is done with a TMS-9902A asynchronous communications controller (ACC), using the CRU interface hardware.

The ACC, U14, is enabled at pin 17 when the output of U22, pin 14 is asserted low, which happens when the CPU is sending data to or receiving data from the ACC. The CPU sends control information and data to the ACC on a CRU output cycle. The CPU receives control information and data from the ACC on a CRU input cycle. The identification of each bit of data transferred is determined by addresses A1 through A5 with the state of the data for the ACC defined by address bit A0, and the state of the data for the CPU defined on pin 4 of the ACC.

The connection between the Front End and the host computer is made through connector J70. A six-position DIP switch, S1, is used to select between EIA RS-232-C and RS-422 communication types.

RS-232-C COMMUNICATION

When RS-232-C communication is used, the host sends characters to J70, pin 3. The EIA voltage-level signal is converted to TTL signal levels by U6, a quad line receiver, and passed to U14, pin 3. When the ACC detects that a character has been received, the CPU is notified with an interrupt and inputs the character from the ACC. The Clear to Send (CTS) and Data Set Ready (DSR) signals from the host computer are level shifted by U6 and passed to U14 on pins 7 and 6, respectively. When the ACC has a character to send to the host computer, the signal is output with the configuration switch-selected characteristics on pin 2 of U14, the ACC. This TTL-level signal is converted to EIA voltage levels by U5, a quad line driver, and passed to J70, pin 2 for reception by the host computer. The Request to Send (RTS) signal from U14, pin 5 is level shifted by U5 and passed to J70, pin 4. This communication takes place provided all of the RS-232-C control signals are asserted properly. If a "three wire connection" is used to the host, U6 is biased to interpret these open inputs as asserted and provides the appropriate control inputs to U14, the ACC. Capacitors C3, C7 and C8 along with resistors in resistor networks Z4 and Z5 provide noise filtering at U6.

RS-422 COMMUNICATION

When RS-422 communication is used, the host sends characters to J70, pins 14 and 15. The differential voltage input is converted to TTL signal levels by U3, a dual differential line receiver, and passed to U14, pin 3. The response of U14 from this point is the same as for RS-232-C. An output character from the ACC, is converted from TTL levels to a differential voltage level by U7, a dual differential line driver, and passed to J70, pins 9 and 10. Line drive is improved by using both drivers of U7 in parallel and resistively coupling their outputs with R16 through R19 to allow for a non-fatal driver failure. Resisters R20 and R21 provide current limit protection. Resistors R13 and R15 provide line termination for receive inputs. Resistors R12 and R14 provide a defined input for U3 when the inputs are left open.

PRINTER COMMUNICATION

The RS-232-C printer port is used to log data to a local display (CRT terminal) or recording (printer) device. The actual data to be sent can be controlled by configuration information entered by the user when the application is being set up.

When this port is used, the microprocessor (U20) sends transmitted data, in order, to U13 (UART), U10, and connector J71, pin 2. U10 accepts the TTL logic levels from the UART and outputs EIA RS-232-compatible voltage levels. Modem control line RTS(L) follows a similar path from UART through U10 to J71, pin 4.

The received data line reaches receiver U2 through J71, pin 3. U2 converts EIA RS-232 voltage levels to TTL-compatible levels, which are applied first to UART U13 and then to the microprocessor (U20).

The printer port receive line can be used to implement X-ON/X-OFF flow control by the receiving device if there is danger of losing data. However, this technique is not normally desirable since it may delay performance of other, more important, Helios tasks.

Modem control lines DSR(L) and CTS(L) are routed from the external device to receiver U4 through J71, pins 6 and 5, respectively. U4 converts EIA RS-232 voltage levels to the TTL-compatible levels that are applied to UART U13.

Modem control lines (DSR(L), CTS(L) and RTS(L)) may be used by the receiving device to implement flow control, but the same drawbacks as described for X-ON/X-OFF flow control apply.

NOTE

Due to its transmit-only nature, the printer port should not be used with a standard modem. A null-modem cable is permissible for the printer port.

Serial Link Communication Circuit

The serial link communication circuit provides the interface between the CPU and the RS-422 serial communication channel with its associated measurement and control options (referred to as serial link devices). Data exchange with the CPU is accomplished with a TMS-9902A asynchronous communications controller (ACC), using the CRU interface hardware.

The ACC, U11, is enabled at pin 17 when the output of U22, pin 13 is asserted low, which happens when the CPU is sending data to or receiving data from the ACC. The CPU sends control information and data to the ACC on a CRU output cycle. The CPU receives control information and data from the ACC on a CRU input cycle. The identification of each bit of data transferred is determined by addresses A1 through A5 with the state of the data for the ACC defined by address bit A0, and the state of the data for the CPU defined on pin 4 of the ACC.

The interconnection of the Computer Interface Assembly and serial link devices installed in the Front End is made through P12 (via the Motherboard PCA). The interconnection of the Computer Interface Assembly and serial link devices installed in Extender Chassis is made through J23 (via appropriate cabling).

A character for output on the serial link that has been transferred to U11, the ACC, is serially output by U11 on pin 2 and converted from TTL levels to RS-422 differential voltage levels by U1, a dual differential line driver. Line drive is improved by using both drivers of U1 in parallel and resistively coupling their outputs with R4 through R7 to allow for a non-fatal driver failure. CR4 through CR7 provide voltage protection for U1, and R2 and R3 provide current limit protection.

A character for input from a serial link device is converted from differential voltage levels to TTL-levels by U3, a dual differential line receiver, and passed to U11, pin 3. When U11 detects that a character has been received, the CPU is notified with an interrupt and inputs the character from the ACC. Resistors R8 through R11 provide line termination for the receive inputs. Diodes CR8 through CR11 provide voltage protection for U3.

Interrupt Control Logic

The serial link ACC operates at 25K baud, so the interrupt on pin 1 is connected directly to the INT1(L) input of U20, pin 15.

The host computer ACC interrupt on pin 1 of U14 is low OR-ed with other possible ACC interrupts to produce a composite interrupt on U9, pin 12. This composite interrupt is connected to the INT4(L) input of U20, pin 14. U12, reserved for future expansion, is not installed; pull-up resistor R23 keeps its line from floating. U13 is used for the printer port with the Scan/Alarm option. Pull-up resistor R22 is installed to keep the INT(L) line from floating in configurations where U13 is not installed (standard Helios 1 configuration without Scan/Alarm).

The INT1(L) input on U20 has a higher priority than the INT4(L) input.

Alarm Annunciator Interface

The Alarm Annunciator PCA is controlled by signals on J73, pins 6 and 3. Pin 6 carries the alarm signal that is driven by U18, pin 12. Refer to the related circuit description under "Clock Interface Circuit." Pin 6 is asserted high when an alarm is detected. It must execute a low-to-high transition each time a new alarm is detected. When all alarms are cleared, pin 6 is asserted low.

Pin 3 is used to clear the alarm annunciator card by asserting a low-to-high transition. This pin is driven by U26, pin 10. Refer to the "Memory Chip Selector" circuit description. Pin 3 is left high during normal operation of the unit.

Power Distribution

Power is delivered to the Computer Interface Assembly from the mainframe power supply by an 8-conductor cable that connects at J75. TP1 through TP4 are provided to monitor the +5V, +12V, and -12V power sources at the Computer Interface Assembly. VR1, a 6V Zener diode, provides protection against voltage transients.

When Front End power is ON, and W9 (the battery power disconnect jumper) connects the negative terminal of the battery to ground, the +5V supply provides +5B through CR1 and charges BT1 through R1 and CR3. When Front End power is OFF, the battery (BT1), supplies +5B through CR2.

Alarm Annunciator PCA

STATE MACHINE

The state machine consists of two flip-flops within U5 and the gates in U3 and U4. Table 9A-5 shows the logic states.

Table 9A-5. Alarm States

STATE	U5 PIN 9	U5 PIN 6	DESCRIPTION
0	Low	Low	No Alarms
1	High	Low	Unacknowledged Alarm
2	High	High	Acknowledged Alarm
3	Low	High	Alarm Cleared
4	Low	Low	No Alarms

Computer Interface Assembly software initializes the state machine to
state 0 by holding J77, pin 6 low while forcing a low-to-high transition
on J77, pin 3. State 0 is maintained until J77, pin 6 goes high, which
causes the transition to state 1. The state machine then remains at
state 1 until an alarm condition is acknowledged. Once an alarm is
acknowledged, the state machine advances to state 2. State 2 is
maintained until J77, pin 6 goes low, which advances the state machine
first to state 3 and then automatically back to state 0. Note that state
3 is only a transition state, used to prevent accidental transition from
state 2 to state 1.

The two outputs from the state machine control the alarm relays as shown
in Table 9A-6.

Table 9A-6. Alarm Outputs

STATE	AUDIBLE ALARM	VISUAL ALARM
0	OFF	OFF
1	On Steady	ON and OFF
2	OFF	On Steady
3	OFF	OFF

RELAY DRIVERS

The relay drivers consist of U6, part of U3, and protection diodes CR2
and CR3. The gate used in U3 controls the clock signal input from U1.
Inputs from U5, pins 6 and 9 control the drivers as defined in Table
9A-5.

RELAYS

The two output relays are mounted in sockets on the Alarm Annunciator
PCA. The relays are rated at 10,000,000 operations at either 0.6A for
120V ac or 1A for 30V dc.

CLOCK

The clock, consisting of CMOS oscillator U1, capacitors C1 and C3, and
timing resistor R5, outputs a signal to the relay drivers of
approximately 1.2 Hz. The clock uses separate ground and voltage supply
lines along with noise-suppression capacitors C4 and C6 to protect
against noise propagation from the oscillator.
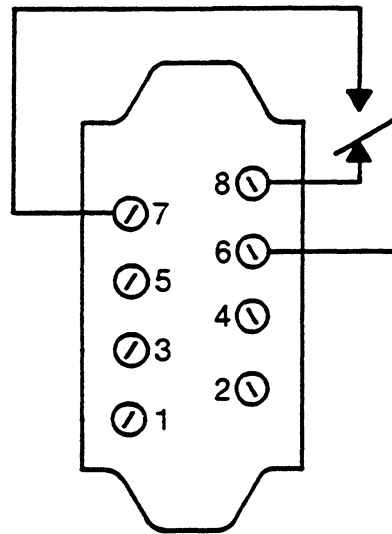
ALARM ACKNOWLEDGE CIRCUIT

CAUTION

An SPDT switch must be used for the alarm
acknowledge pushbutton. This arrangement requires
that an alarm be acknowledged, which can be a very
important safety consideration. The acknowledge
pushbutton must not be hard wired closed.

Alarm acknowledgment requires a single-pole, double-throw switch (SPDT)
allowing for the following sequence:

1. Connection of pin 6 to pin 8.
2. Disconnection of pin 6 from pin 8.
3. Connection of pin 6 to pin 7.
4. Disconnection of pin 6 from pin 7.
5. Reconnection of pin 6 to pin 8.

This switch arrangement prevents permanent wiring of alarm acknowledge
contacts in the acknowledged position. See Figure 9A-4.

WARNING

TO AVOID ELECTRICAL SHOCK, DISCONNECT ALL EXTERNAL
POWER SOURCES BEFORE MAKING ANY ALARM CONNECTIONS.

Figure 9A-4. Alarm Acknowledge Switch Connections

Two flip-flops in U2 form the alarm acknowledge pushbutton interface. The first U2 flip-flop must be set and then cleared to generate the low-to-high signal used as the input to the second U2 flip-flop. If the state machine is in state 1 or state 2 at this time, a high is clocked into the second U2 flip-flop, in turn causing U2, pin 9 to go high. If the state machine was in state 1, this action causes the state machine to advance to state 2, acknowledging the alarm. The pushbutton inputs use pullup resistors R1 and R2. Resistor R3 is used to bias the unused U2, pin 10 high.

GENERAL MAINTENANCE

Line Voltage Selection

WARNING

THE FOLLOWING PROCEDURE REQUIRES ACCESS TO THE INTERIOR OF THE COMPUTER FRONT END. DO NOT PERFORM THIS PROCEDURE UNLESS YOU ARE QUALIFIED TO DO SO. LETHAL VOLTAGES MAY EXIST WITHIN THE UNIT.

The power input setting (110V or 220V) is normally marked on the support panel of the Computer Interface Module, just above the power input connector. If there is no mark in either box, or if the box is marked for a voltage other than the one you will be using, use the following procedure to gain access to the internal setting.

1. Turn the Computer Front End power switch to OFF.

2. Remove the ac input line cord from the power source and from the Computer Front End.

3. Remove the four Phillips-head screws indicated in Figure 9A-5.

4. Remove the Computer Interface Module from the chassis by grasping the finger indentation in the fan filter hole and sliding the module straight back and out.

5. Locate the Line Power Voltage Pins on the Power Supply PCA (Figure 9A-6). To select 180-264V operation, connect the wire to the pin marked 220V. For 90-132 operation, place the wire on the pin labeled 110V. It is not necessary to change the power input fuse when changing the power supply operating voltage.

6. While the Computer Interface Module is out, locate the Line Frequency Selection Switch, S3-8, (see Figure 9A-7) to ensure that it is set to the local line frequency.

    If the switch is not set to the local line frequency, set it properly before continuing. For 50-Hz operation, place S3-8 in the ON position (up). For 60-Hz operation, place the switch in the OFF (down) position.
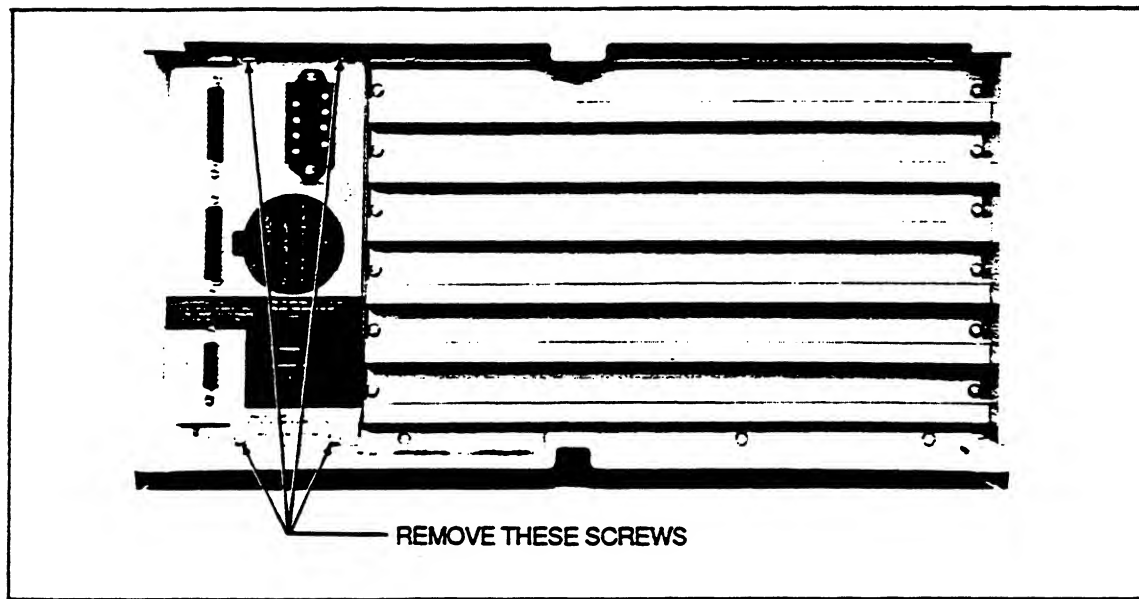
Figure 9A-5. Computer Interface Module Supply Removal Screws

Figure 9A-6. Line Power Voltage Pins

HELIOS I (SCAN/ALARM OPTION)

Host Computer
Port

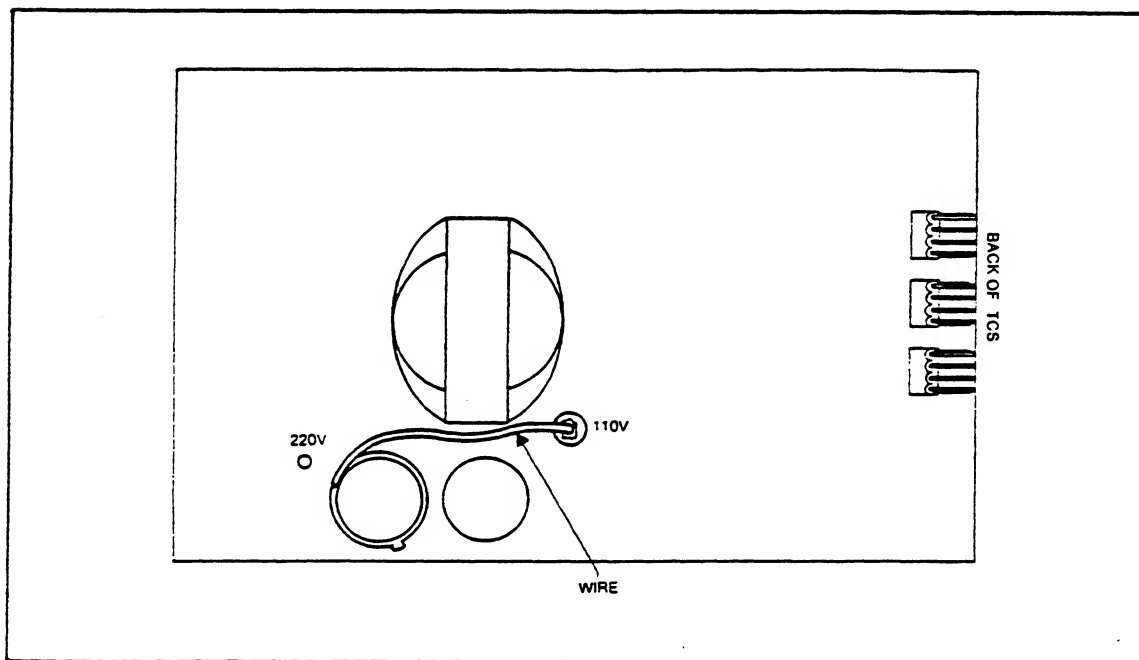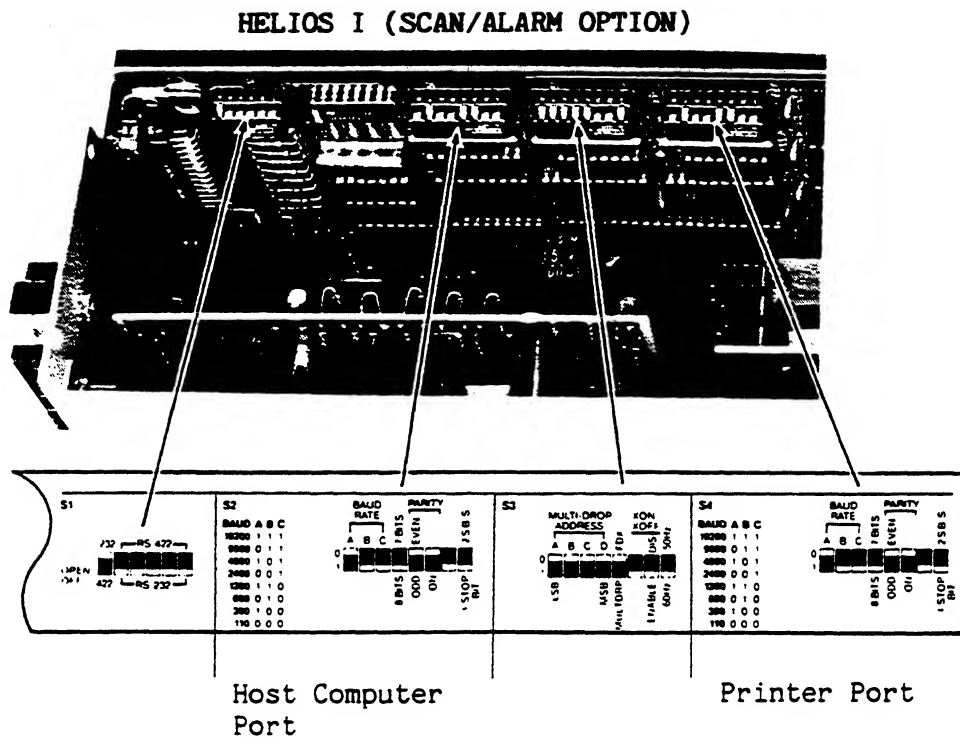Printer Port

Figure 9A-7. Communication Parameter Selection Switches

7. After changing the line power voltage, mark the appropriate power
    setting on the support panel of the module, (above the ac input
    socket).

8. Slide the Computer Interface Module back into the Front End, and
    reinstall the Phillips-head screws.

Fuse Replacement

The fuse is located on a clip-type holder on the power supply assembly, in the corner to the right of the 110V voltage selection pin. When replacing the fuse, use the same value (2.0A, 250V). To check or replace the fuse, perform the following:

1. Switch OFF power to the Front End and disconnect the ac line cord and other high voltage input.

2. Remove the Computer Interface Module as described in steps 3 and 4 of the Line Voltage Selection procedure (above).

3. Use a slotted screwdriver or adjustment tool to remove the fuse.

4. After checking or replacing the fuse, reinstall the Computer Interface Module in the Front End chassis and test its operation.

<div align="center">NOTE</div>

If the fuse is bad, it is probable that the power supply is also bad. Remember that the Power Supply is a replaceable, but not repairable, item. If a replacement fuse fails, contact a Fluke Service Center.

Cleaning

<div align="center">CAUTION</div>

Before cleaning or servicing the Computer Interface Assembly, disconnect back-up battery power by moving the W9 jumper as shown in Figure 9A-8.

Refer to Section 4 of this manual for general and pca-specific cleaning instructions. Fan filter cleaning is also covered in Section 4.
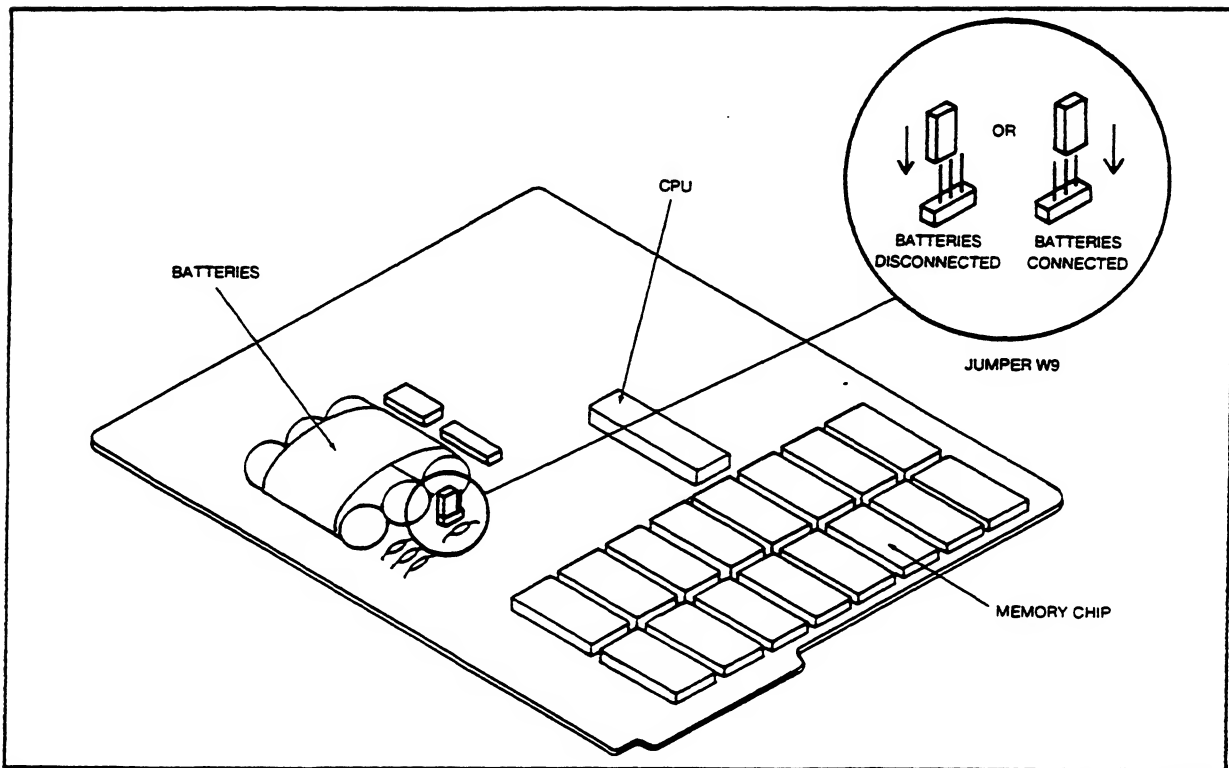
Figure 9A-8. W9 Battery Power Jumper

Access, Removal, and Reinstallation

Most Helios access, removal, and reinstallation techniques are identical for the Front End with or without the Scan/Alarm Option. Refer to this common information under the following headings in Section 4 of this manual:

o   Access to Options

o   Removing and Reinstalling the Top and/or Bottom Cover

o   Removing and Reinstalling the Front Panel

o   Removing and Reinstalling the Motherboard

Power Supply Adjustments

The power supply voltage levels do not normally require calibration, although some minor service adjustments may occasionally be necessary. Refer to Section 5 for power supply adjustment procedures.

Removing and Reinstalling the Power Supply

WARNING

**THERE ARE LETHAL VOLTAGES AT VARIOUS POINTS ON
THE POWER SUPPLY. EXERCISE EXTREME CAUTION WHEN
SERVICING. DISCONNECT THE FRONT END FROM LINE
POWER AND DISCHARGE ALL CAPACITORS AS SOON AS THEY
ARE ACCESSIBLE.**

The Power Supply PCA is mounted on the Computer Interface Module (Figure 9A-9). To access the Power Supply PCA, use the following procedure:

1. Switch OFF power to the Front End, and disconnect the ac line cord from the support panel input connector.

2. Remove the four Phillips-head screws (shown in Figure 9A-5) that secure the Computer Interface Module to the mainframe chassis.

3. Remove the Computer Interface Module from the chassis by grasping the finger indentation in the fan filter hole and sliding the module straight back and out.

WARNING

**THERE MAY BE DANGEROUS VOLTAGES ROUTED THROUGH THE
ALARM ANNUNCIATOR CONNECTOR. DISCONNECT EXTERNAL
POWER FROM THESE ANNUNCIATOR CONNECTIONS BEFORE
PROCEEDING.**

4. Remove the two Phillips-head screws securing the alarm annunciator connector to the panel. Then pull the connector out, disconnecting it from the Alarm Annunciator PCA.

5. Disconnect the wires leading from the Alarm Annunciator PCA to the Computer Interface PCA.

6. The Power Supply PCA is secured to the right panel of the Computer Interface Module by four Phillips-head screws.

    Rotate this panel down from the support panel of the Computer Interface Module by first removing the upper nut (on the back of the support panel) and then loosening the lower nut.

7. Disconnect all leads connecting the power supply to the Computer Interface Assembly, power switch and fan assembly.

8. To detach the power supply from the panel, remove four Phillips-head screws, one in each corner of the power supply.

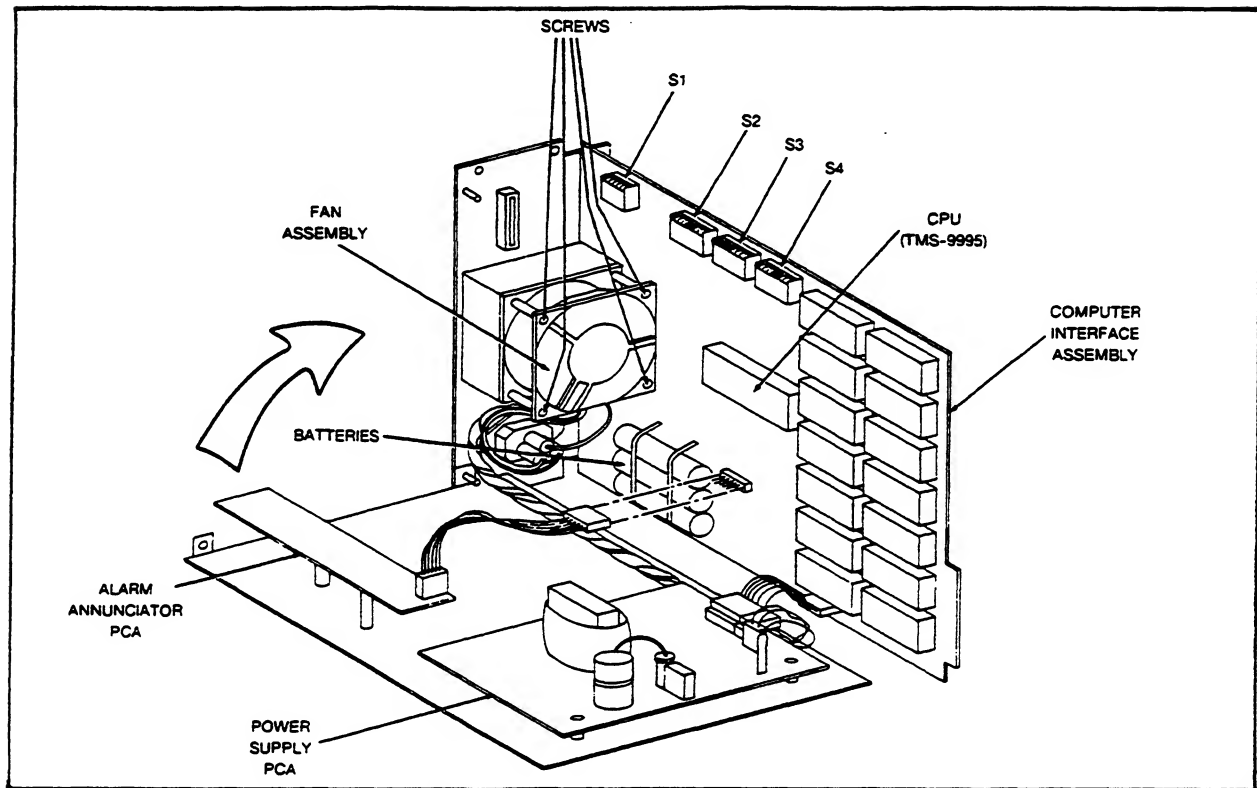Reverse the previous steps to reinstall the Power Supply.

SCREWS
S1
S2
S3
S4
CPU
(TMS-9995)
FAN
ASSEMBLY
COMPUTER
INTERFACE
ASSEMBLY
BATTERIES
ALARM
ANNUNCIATOR
PCA
POWER
SUPPLY
PCA

Figure 9A-9. Computer Interface Module (Interior)

Removing and Reinstalling the Computer Interface Assembly

CAUTION

Handle the Computer Interface Assembly with care,
or some semiconductors and ICs can be damaged by
electrostatic discharge during handling. Refer to
the static awareness information at the beginning
of Section 4 for proper handling precautions.

The Computer Interface Assembly is mounted on the Computer Interface
Module (see Figure 9A-9). Use the following procedure to access the
Computer Interface Assembly:

1. Perform steps 1 through 3 of the Removing and Reinstalling the Power
    Supply procedure.

2. Disconnect all leads to the Computer Interface Assembly.

3. Place jumper W9, shown in Figure 9A-8, in the "batteries
    disconnected" position.

4. The Computer Interface Assembly is secured to the left panel of the
    Computer Interface Module by six hex-head screws above and below
    the HOST COMPUTER, PRINTER, and EXTENDER chassis connectors.

    Remove the hex-head screws to detach the Computer Interface
    Assembly from the side panel.

NOTE

The Computer Interface Assembly should be stored
and transported in an anti-static bag.

Reinstall the Computer Interface Assembly by reversing these steps.

Removing and Reinstalling the Fan Assembly

To remove the fan assembly (shown in Figure 9A-9), perform the following
procedure:

1. Perform steps 1 through 6 of the Removing and Reinstalling the
    Power Supply procedure.

2. Disconnect the red and blue leads between the power supply and fan
    assembly if this has not already been done.

3. To detach the fan assembly (and the fan filter housing) from the
    support panel of the Computer Interface Module, remove the four
    screws (shown in Figure 9A-9) that secure the fan assembly and
    filter housing to the panel.

To reinstall the fan assembly reverse the previous steps.

Removing and Reinstalling the Alarm Annunciator Assembly

Complete steps 1 through 6 of the "Removing and Reinstalling the Power
Supply" procedure. Then remove the two screws securing the Alarm
Annunciator PCA to the right panel.

PERFORMANCE TEST

Two performance tests in addition to the Mainframe Tests are required to
verify correct operation of the Scan/Alarm Option. These additional
tests are the Alarm Annunciator Test and the Printer Output Test.

Table 9A-7. Required Test Equipment (Scan/Alarm Option)

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	3 to 4.2V dc $\pm$0.001V	Fluke 343
Digital Multimeter (DMM)	Resistance Measurement	Fluke 77 or equivalent
A/D Converter	na	Fluke Option -161 (no substitute)
Thermocouple DC Volts Scanner	na	Fluke Option -162 (no substitute)
Input Connector	na	Fluke Option -175 or -176 (no substitute)
Printer or Display Monitor	RS232 Compatible	most brands
Switch	Single Pole, Double Throw	Fluke PN 493825

Alarm Annunciator Test

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURE.

The Alarm Annunciator test verifies that the Alarm Annunciator Assembly is functioning properly. Because this test is dependent on voltage readings, the accuracy verification test of the -162 Thermocouple/DC Volts Scanner should be performed if voltage readings are suspect.

1. Perform the Mainframe Performance Test in Section 5 of this manual.

2. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

3. Wire an Alarm Acknowledgement Switch (single pole, double throw) to the Alarm Annunciator Terminal Strip as shown in Figure 9A-10.

4. Set the -161 A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the -162 Thermocouple/DC Volts Scanner in the option slot immediately below.

5. Remove all other installed options to eliminate addressing conflict.

6. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

   Install the connector on the scanner.

7. Reconnect the Front End's ac line cord and switch the power ON.

8. Connect the calibrator output to the input connector test leads.

9. Set the calibrator output to 3.0000V dc.

WARNING

TO AVOID ELECTRICAL SHOCK, DISCONNECT ALL EXTERNAL POWER SOURCES BEFORE MAKING ANY ALARM CONNECTIONS.
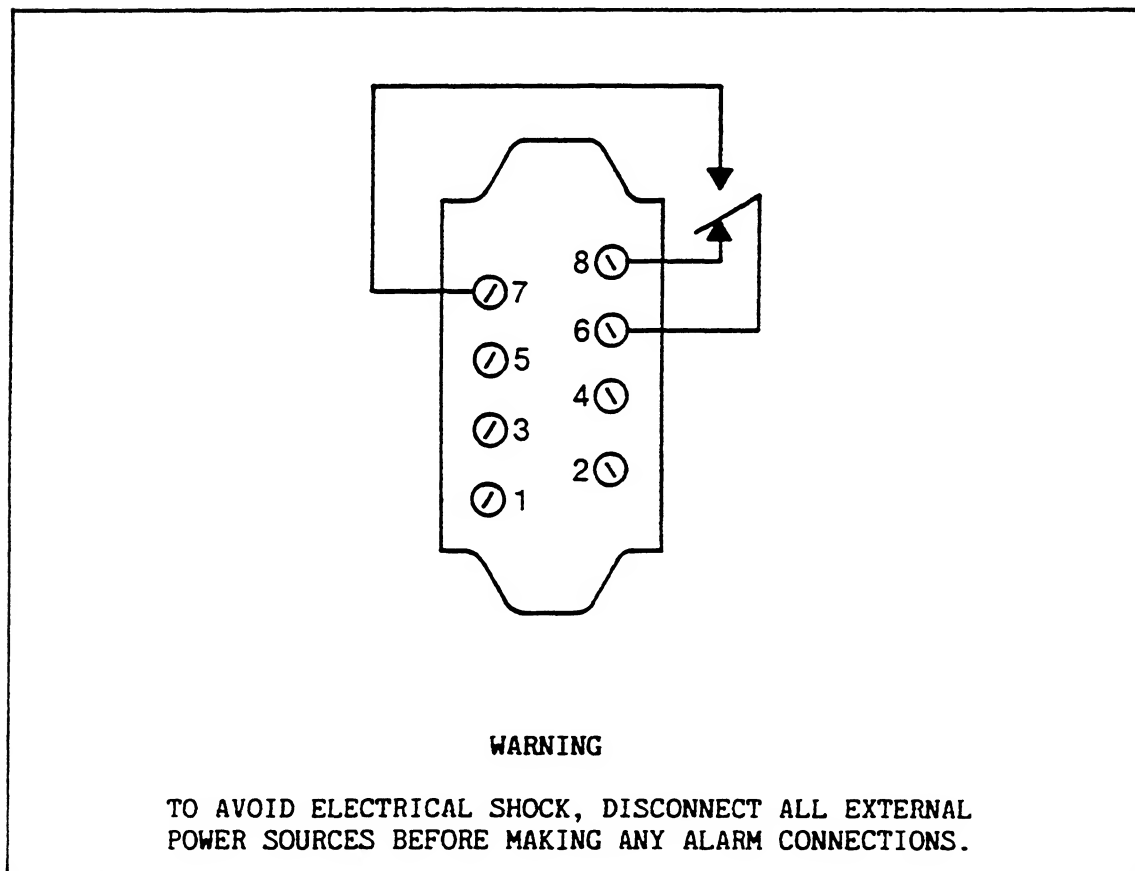
Figure 9A-10. Alarm Annunciator Test

NOTE

Prior to performing steps 10 and 11, check that
the terminal screws are tightened securely.
This check ensures good continuity.

10. With the DMM set to a resistance function, measure for an OPEN
across terminals 1 and 3 (audible contacts) of the Alarm
Annunciator Terminal Strip.

11. Move the DMM test leads across terminals 2 and 4 (visual contacts)
of the Alarm Annunciator Terminal Strip. Check that an OPEN is
measured.

12. Program the Front End using either a terminal or a computer. (You
can also run a terminal emulation program to use a computer
behaving as a terminal.) For ease of testing, a terminal is the
recommended host.

Use either PROCEDURE A or PROCEDURE B depending on whether
performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host,
send the following commands to the Front End.

```
MODE=TERM    <CR>
DEF CHAN(0)=DVIN,MAX=5,HI=4,LO=2,HYST=5    <CR>
FORMAT=XASCII  <CR>
SEND CHAN(0)    <CR>
```

The value returned for channel(000) should be 3.00000E+00 +/- 0.0012 V.

Repeat steps 10 and 11, checking that relay contacts remained OPEN.

A1. Set the calibrator to output 4.2000V dc.

A2. Again send the command:

SEND CHAN(0) <CR>

The response for channel 0 should be approximately 4.20000E+00
with the text "hi alarm" appended.

A3. Using the DMM as an ohmmeter, measure a contact closure across
terminals 1 and 3 (audible contacts) of the Alarm Annunciator
Terminal Strip.

A4. Move the DMM test leads to measure-across terminals 2 and 4
(visual contacts). The DMM should indicate closure and opening
of the contacts at approximately an 800 millisecond rate.

A5. Acknowledge the alarm by switching the Alarm Acknowledgement Switch so that its normally open (N/O) contact makes continuity with common, then switch back to the normally closed (N/C) position.

A6. With the DMM, check that an OPEN is measured across the audible contacts (terminals 1 and 3).

A7. Move the DMM test leads to measure across the visual contacts (terminals 2 and 4). They should now be shorted (closed).

A8. Set the calibrator to output 3.8000V dc.

A9. Command the Front End to take another measurement on channel 0 by issuing the following command:

   SEND CHAN(0) <CR>

   Verify the response is approximately 3.80000E+00 without any alarm message.

A10. Check that both the audible (terminals 1 and 3) and the visual (terminals 2 and 4) contacts now measure an OPEN.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a DC voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A enter a program that will run on your host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
100   GOSUB 300
120   PRINT #1,"def chan(0)=dvin,max=5,hi=4.0,lo=2.0,hyst=5"
130   GOSUB 300
140   PRINT #1,"format=xascii"
150   GOSUB 300
160   REM make measurement and read in response
```

```
170    PRINT #1,"send chan(0)"
180    INPUT #1,M$
190    L$=LEFT(M$,9)
200    X$=MID(M$,10,13)
210    R$=RIGHT(M$,11)
220    PRINT L$;
230    PRINT USING "##.######";VAL(X$);
240    PRINT R$
250    END
300    REM wait for message accepted prompt
310    INPUT #1,A$
320    IF A$<>"!" THEN GOTO 310
330    RETURN
```

Program FOR 1722A:

```
10     CLOSE 1,2
20     PRINT CHR$(27);"[2J";
30     REM open communication port and empty Front End buffer
40     OPEN "KB1:"AS NEW FILE 1%
50     OPEN "KB1:"AS OLD FILE 2%
60     PRINT #1,CHR$(3);
70     REM set up Computer Front End
80     PRINT #1,"mode=comp"
90     GOSUB 300
100    PRINT #1,"count=off"
110    GOSUB 300
120    PRINT #1,"def chan(0)=dvin,max=5.0,hi=4.0,lo=2.0,hyst=5"
130    GOSUB 300
140    PRINT #1,"format=xascii"
150    GOSUB 300
160    REM make measurement and read in response
170    PRINT #1,"send chan(0)"
180    INPUT #2,M$
190    L$=LEFT(M$,9%)
200    X$=MID(M$,10%,12%)
210    R$=RIGHT(M$,24%)
220    PRINT L$;
230    PRINT USING "S##.######",VAL(X$);"Volts dc   ";
240    PRINT R$
250    END
300    REM wait for message accepted prompt
310    INPUT #2,A$
320    IF A$<>"!" THEN GOTO 310
330    RETURN
```

The returned value for channel 000 should be 3V +/- 0.012V.

B1.   Set the calibrator to output 4.2000V dc.

B2.   Take another measurement by RUNing the program again.

The response should show the measured value plus "hi alarm".

B3. Perform steps A3 through A7.

B4. Set the calibrator to output 3.8000V dc.

B5. Run the program and check that the measured value is 3.8V. No alarm message should now be returned.

B6. Check that both the audible (terminals 1 and 3) and the visual (terminals 2 and 4) contacts measure OPEN.

13. This completes the Alarm Annunciator Performance Test.

14. Continue with the Printer Output Performance Test if you are performing a complete Scan/Alarm Option Test.

Printer Output Test

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURE.

The Printer Output Test verifies that the Printer Port on the Scan/Alarm Option is functioning properly.

1. If you have not yet performed the Mainframe Test please do so now.

NOTE

S4 must be configured to match the communication parameters of the printer or display monitor.

2. Using an RS232 null cable (Y1702 or equivalent) connect an RS232 printer or display monitor to the printer port of the Scan/Alarm module. Check that power to the device is turned ON.

3. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

MODE=TERM   <CR>

COUNT=OFF   <CR>

FORMAT=XASCII   <CR>

DEF CHAN(0)=DVIN,MAX=5,HI=4,LO=2,HYST=5   <CR>

DEF SCAN(0)=CHAN(0)   <CR>

START SCAN(0),OUTPUT=PRINTER,INTERVAL=10   <CR>

A1. Check that the Printer Port outputs SCAN(0) information at a ten second interval.

SCAN information will include: Date, Time, Scan(#), Chan(#), Measured Value, and Status (if an error or alarm occurs).

A2. Send the command:

STOP SCAN(0) <CR>

Printer port output should now cease.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a DC voltage measurement on selected channel(s) and output the scan data to the Printer Port. One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A enter a program that will run on your host.

Program for IBM PC:

```
10    CLOSE 1
20    CLS
30    REM open communication port, empty Front End buffer
40    OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50    PRINT #1,CHR$(3);
60    REM set up Front End
70    PRINT #1,"mode=comp"
80    GOSUB 300
90    PRINT #1,"count=off"
100   GOSUB 300
120   PRINT #1,"def chan(0)=dvin,max=5,hi=4.0,lo=2.0,hyst=5"
130   GOSUB 300
140   PRINT #1,"format=xascii"
150   GOSUB 300
160   PRINT #1,"def scan(0)=chan(0)"
170   GOSUB 300
180   REM Scan channel 0 and send response to printer port
190   PRINT #1,"start scan(0),output=printer,interval=10"
200   SOUND 32767,920
210   PRINT #1,"stop scan(0)"
220   END
300   REM wait for message accepted prompt
310   INPUT #1,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

Program FOR 1722A:

```
10    CLOSE 1,2
20    PRINT CHR$(27);"[2J";
30    REM open communication port and empty Front End buffer
40    OPEN "KB1:"AS NEW FILE 1%
50    OPEN "KB1:"AS OLD FILE 2%
60    PRINT #1,CHR$(3);
70    REM set up Computer Front End
80    PRINT #1,"mode=comp"
90    GOSUB 300
100   PRINT #1,"count=off"
110   GOSUB 300
120   PRINT #1,"def chan(0)=dvin,max=5.0,hi=4.0,lo=2.0,hyst=5"
130   GOSUB 300
140   PRINT #1,"format=xascii"
150   GOSUB 300
160   PRINT #1,"def scan(0)=chan(0)"
170   GOSUB 300
180   REM scan channel 0 and send response to printer port
190   PRINT #1,"start scan(0),output=printer,interval=10"
200   WAIT 50000
210   PRINT #1,"stop scan(0)"
220   END
300   REM wait for message accepted prompt
310   INPUT #2,A$
320   IF A$<>"!" THEN GOTO 310
330   RETURN
```

B1. Verify that the Printer Port outputs SCAN(0) information.

Scan information includes: Date, Time, Scan(#), Chan(#), Measured Value, and Status (if an error or an alarm has occurred).

B2. This completes the Printer Output Test.

## LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Scan/Alarm option is provided in Tables 9A-8 through 9A-10 and Figures 9A-11 through 9A-13. For parts ordering information, see Section 6 of this manual.

Figure 9A-14 presents a schematic diagram for the A1 Computer Interface PCA. Figure 9A-15 is a schematic diagram of the A2 Alarm Annunciator PCA.

Table 9A-8. Scan Alarm Computer Interface Module
(See Figure 9A-11.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK -NO-	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-	TOT QTY-	R S -Q	N O T -E-
A	1	• COMPUTER I/F ASSY. FOR SCAN/ALARM	822932	89536	822932	1		
A	2	• ALARM ANNUNCIATOR ASSY	822924	89536	822924	1		
BT	1	POWER SUP,40W,+5@3.5A,+12@2A,-12@1A	769406	89536	769406	1		
E	1	TERM,RING #6,3/32 - 2 PLACES,SOLDR	132399	78189	2104-06-00	2	1	
E	2	TERM,FASTON,REC, 19-22 AWG,CRIMP,INS	331041	89536	331041	1		
E	3	TERM,FASTON,REC,18-22AWG,.187W,INSUL	747485	89536	747485	4		
H	1	FILTER,AIR	793596	89536	793596	1		
H	2	CONN ACC,D-SUB,JACK SCREW,4-40	448092	89536	448092	6		
H	3	SCREW,MACH,SEMS,PH,P,STL,6-32X0.750	309963	89536	309963	2		
H	4	SCREW,MACH,SEMS,PH,P,STL,6-32X0.625	272591	89536	272591	4		
H	5	WASHER,FLAT,STEEL,0.149X0.375X0.031	110270	89536	110270	4		
H	6	WASHER,LOCK,SPLIT,STEEL,#6	110692	89536	110692	2		
H	7	NUT,MACH,HEX,STL,6-32	110551	89536	110551	2		
H	8	SCREW,MACH,RH,SL,STL,6-32X2.250	114421	89536	114421	4		
H	9	WASHER,LOCK,INTRNL,STEEL,#6	110338	89536	110338	4		
H	10	NUT,MINI,HEX,SS,6-32	110569	89536	110569	2		
H	11	WASHER,FLAT,NYLON,0.150IDX0.312X0.031	559013	89536	559013	2		
H	12	WASHER,LOCK,INTRNL,STEEL,#4	110403	89536	110403	2		
H	13	WASHER,FLAT,BRASS,#4,0.025	110775	89536	110775	2		
H	14	SCREW,MACH,PH,P,STL,4-40X1.000	157008	73734	19030	1		
H	15	NUT,MACH,HEX,STL,4-40	110635	89536	110635	2		
MP	1	CONN,PWB EDGE,REC,T BLK,0.156 C,8 POS	820803	89536	820803	1		
MP	2	COVER, CONN. SCAN/ALARM	822908	89536	822908	1		
MP	3	SHIELD, CARD GUIDE	793448	89536	793448	1		
MP	4	SHROUD, FAN	793570	89536	793570	1		
MP	5	RETAINER, FILTER	793588	89536	793588	1		
MP	6	REAR PANEL, SCAN/ALARM	819185	89536	819185	1		
MP	7	SPACER,RND,ALUM,0.156IDX0.750	100966	89536	100966	4		
MP	8	SLEEV,POLYOL,SHRINK,.125-.062ID,BLACK	149450	89536	149450			
MP	9	SLEEV,POLYOL,SHRINK,.187-.093ID,BLACK	113852	89536	113852			
MP	10	CABLE TIE ANCHOR,ADHSV,0.160"TIE	407908	89536	407908	2		
MP	11	CABLE TIE,4"L,0.100"W,0.75 DIA	172080	89536	172080	2		
MP	12	HOUSING PART,TERM,FOR 0.045,18-24 AWG	376368	89536	376368	2		
MP	13	HOUSING,1 ROW,0.156 CTR,LOCK,3 POS	380493	89536	380493	1		
MP	14	PWR PLUG PART,CRIMP TERMINAL	474619	89536	474619	3		
MP	15	PWR PLUG PART,HOUSING	474668	89536	474668	1	1	
S	1	SWITCH,ROCKER,DPST	615054	89536	615054	1	1	
W	1	WIRE,PVC,UL1015,22AWG,BTIN,BLK	115345	89536	115345	1		
W	2	WIRE,PVC,UL1015,22AWG,BTIN,WHT	115378	89536	115378	1		
W	3	WIRE,TEF,EE,UL1180,18AWG,STRN,GRN/YEL	386177	89536	386177	1		
W	4	CABLE, POWER SUPPLY	793612	89536	793612	1		
W	5	ASSY, FAN CABLE	794636	89536	794636	1		
W	6	CABLE ASSY. ALARM ANNUNCIATOR	819193	89536	819193	1		

An • in 'S' column indicates a static-sensitive part.

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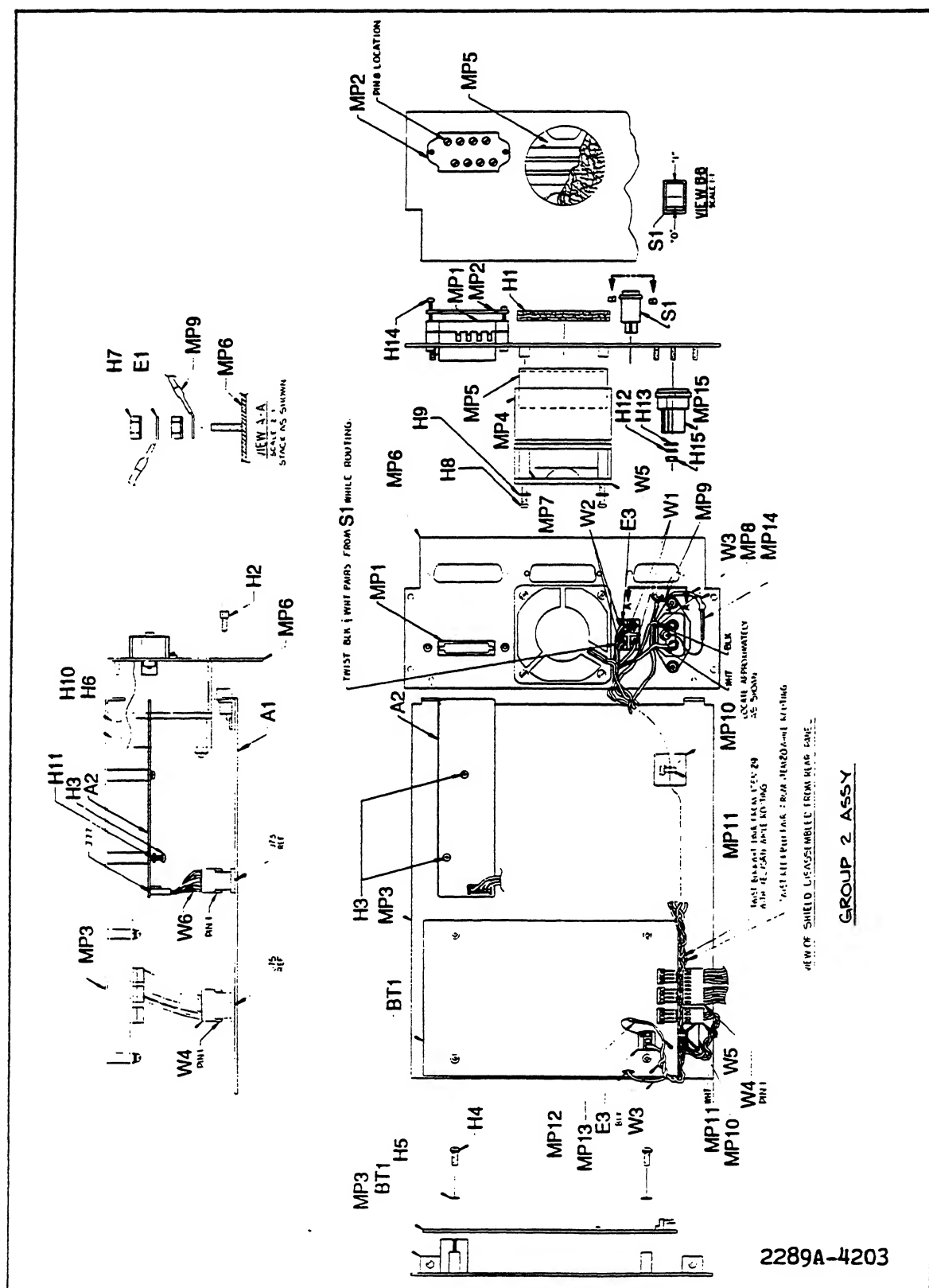
Figure 9A-11. Scan/Alarm Computer Interface Module

Table 9A-9. A1 Scan Alarm Computer Interface PCA
(See Figure 9A-12.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK -NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
BT 1		BATTERY,NI-CAD,3.6V,0.45AH	615476	57053	41B020AD01501	1	
C 1- 8, 10-		CAP,CER,330PF,+-5%,100V,COG	528620	04222	SR151A331JAA	12	
C 13			528620				
C 9, 17, 20-		CAP,CER,0.22UF,+-20%,50V,25U	519157	04222	SR205E224MAA	22	
C 39			519157				
C 14		CAP,CER,0.01UF,+-20%,100V,X7R	407361	04222	SR201C103MAA	1	
C 15		CAP,CER,10PF,+-5%,100V,COG	566042	04222	SR151A100JAA	1	
C 16		CAP,CER,39PF,+-2%,100V,COG	512962	04222	SR151A390GAA	1	
C 18, 19		CAP,CER,18PF,+-2%,100V,COG	512335	51406	RPE110A184G1	2	
CR 1- 3	*	DIODE,SI,SCHOTTKY BARRIER,SMALL SIGNL	523738	28480	5082-2835	3	
CR 4- 11		DIODE,SI,50 PIV,1.0 AMP	379412	04713	1N4933	8	
H 1		RIVET,S-TUB,OVAL,STL,.118,.156	103424	12014	CUP-07826-014-0.146	6	
J 23		CONN,D-SUB,PWB,RT ANG,15 SCKT	707034	00779	747021-5	1	
J 70, 71		CONN,D-SUB,PWB,RT ANG,25 PIN	706218	00779	747022-5	2	
J 73		HEADER,1 ROW,.100CTR,6 PIN	758003	00779	641126-6	1	
J 75		HEADER,1 ROW,.100CTR,8 PIN	800169	00779	640456-8	1	
MP 1		CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	1	
MP 2		CABLE TIE,8"L,0.091"W,2.0 DIA	331157	06383	PLT2M	2	
MP 3		SHUNT BAR,PWB,3 INCH	453613	28213	5020	1	
R 1		RES,CF,100,+-5%,0.25W	348771	59124	CF1/4 101J	1	
R 2, 3, 20,		RES,CF,33,+-5%,0.25W	414524	59124	CF1/4 330J	4	
R 21			414524				
R 4- 7, 16-		RES,CF,51,+-5%,0.25W	414540	59124	CF1/4 510J	8	
R 19			414540				
R 8, 11		RES,CF,5.1K,+-5%,0.25W	368712	59124	CF1/4 512J	2	
R 9, 10, 13,		RES,CF,270,+-5%,0.25W	348789	59124	CF1/4 271J	4	
R 15			348789				
R 12, 14, 22,		RES,CF,47K,+-5%,0.25W	348896	59124	CF1/4 473J	7	
R 23, 30, 32,			348896				
R 33			348896				
R 24		RES,MF,102K,+-0.1%,0.125W,50PPM	293522	91637	CMF-55 1023B T-2	1	
R 25		RES,CF,4.7K,+-5%,0.25W	348821	59124	CF1/4 472J	1	
R 26		RES,MF,37.01K,+-0.1%,0.125W,50PPM	386425	91637	CMF-55 37011B T-2	1	
R 27		RES,CF,180K,+-5%,0.25W	348946	59124	CF1/4 184J	1	
R 28		RES,CF,100K,+-5%,0.25W	348920	59124	CF1/4 104J	1	
R 31		RES,CF,10K,+-5%,0.25W	348839	59124	CF1/4 102J	1	
R 34		RES,CC,2.2K,+-5%,0.5W	108506	01121	EB2225	1	
S 1		SWITCH,DIP,DPST,PIANO,6 POS	800037	00779	1-435802-7	1	
S 2- 4		SWITCH,DIP,SPST,PIANO,SEALED,8 POS	658567	00779	435802-9	3	
TP 1- 4		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	4	
U 1, 7	*	IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	27014	DS1692J	2	
U 2, 4, 6	*	IC,TTL,QUAD RS232C LINE RECEIVER	524850	27014	DS1489AN	3	
U 3	*	IC,LSTTL,QUAD RS422 LINE RCVR,3-STATE	525303	27014	DS3486N	1	
U 5, 10	*	IC,TTL,QUAD RS232C LINE DRIVER	414052	27014	DS1488N	2	
U 8	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	1	
U 9	*	IC,LSTTL,TRIPLE 3 INPUT AND GATE	393082	27014	DM74LS11N	1	
U 11, 13, 14	*	IC,NMOS,ASYNC COMMUNICATION CONTROLLR	483552	01295	TMS9902ANL-40	3	
U 15, 17, 23,	*	IC,LSTTL,8-1 MUX W/3-STATE OUTPUTS	407577	27014	DM74LS251N	4	
U 33			407577				
U 16	*	IC,COMPARATOR,DUAL,LO-POWER,8 PIN DIP	783662	01295	TLC372CP	1	
U 18, 26	*	IC,LSTTL,8BIT ADDRSABLE LATCH,W/CLR	419242	6E570	74LS259N	2	
U 19	*	IC,CMOS,SERIAL I/O CALENDER & CLOCK	586412	33297	uPD4990AC	1	
U 20	*	IC,NMOS,16 BIT MICROCOMPUTER	640417	01295	MP9572N	1	
U 21, 29, 31	*	IC,LSTTL,OCTL LINE DRVR W/3-STATE OUT	429035	01295	SN74LS244N	3	
U 22, 25, 28,	*	IC,LSTTL,3-8 LINE DCDR W/ENABLE	407585	27014	DM74LS138N	4	
U 32	*		407585				
U 24, 27	*	IC,CMOS,3-8 LINE DCDR W/ENABLE	773036	01295	SN74HC138N	2	
U 30	*	IC,LSTTL,OCTL BUS TRNSCVR W/3-ST OUT	477406	01295	SN74LS245N	1	
U 34, 35, 37,	*	IC,CMOS,8KX8 STAT RAM,120 NSEC	754259	44648	KM6264BLP-10	9	
U 39- 43, 47	*		754259				
U 36, 38	*	IC,CMOS,32K X 8 STATIC RAM,120 NSEC	800995	62786	HM62256ALP-12	2	
U 44, 48		IC,32K X 8 EPROM	723783	27014	NM27C256Q200	2	
U 45, 46, 49		IC,NMOS, 8K X 8 EPROM	723569	61394	DQ2764-2	3	
VR 1	*	ZENER,TRANS SUPPRESSOR,6V	508655	11961	1N5908	1	
VR 2	*	IC, 1.23V,150 PPM T.C.,BANDGAP V. REF	634451	27014	LM385Z-1.2D26Z	1	
X 20		SOCKET,IC,40 PIN	429282	00779	2-640379-1	1	
X 34- 49		SOCKET,IC,28 PIN	448217	95146	228AG-39D	16	
XW 7, 9, 11		HEADER,1 ROW,.100CTR,6 PIN	478669	00779	103747-6	3	

An * in 'S' column indicates a static-sensitive part.

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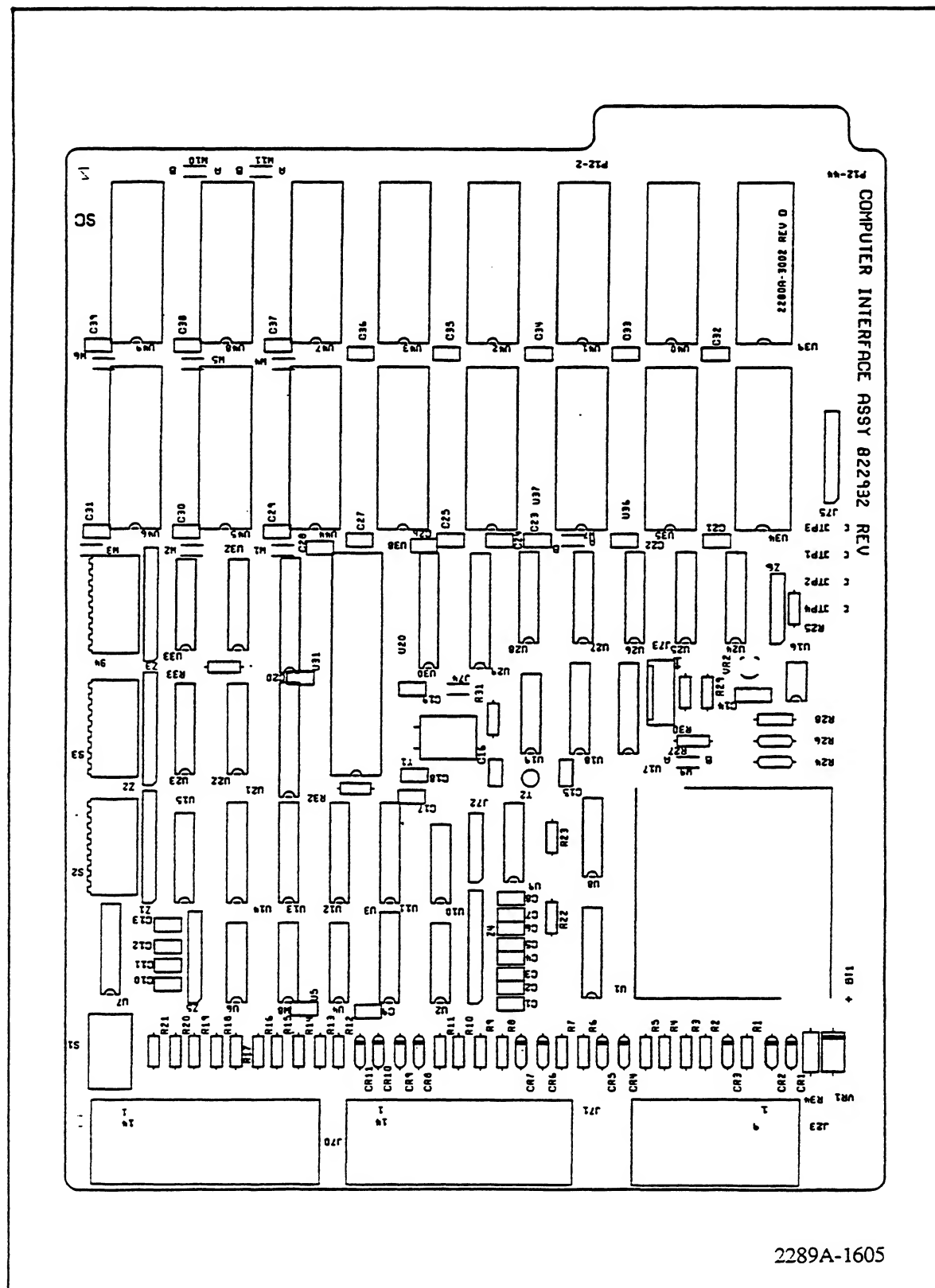
Figure 9A-12. A1 Scan/Alarm Computer Interface PCA

Table 9A-9. A1 Scan Alarm Computer Interface PCA (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	-------------DESCRIPTION-------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	N O T -E-
Y	1		CRYSTAL,11.9808MHZ,+-0.01%,HC-18/U	642777	61429	HC-18/U-11.9808MHZ	1	
Y	2		CRYSTAL,32.768KHZ,+-0.003%	501817	87516	861-T-32.768	1	1
Z	1- 3		RES,CERM,SIP,10 PIN,9 RES,47K,+-2%	485193	91637	CSC10A-01-473G	3	
Z	4		RES,CERM,SIP,10 PIN,9 RES,4.7K,+-2%	484063	91637	CSC10A-01-472G	1	
Z	5		RES,CERM,SIP,8 PIN,7 RES,47K,+-2%	413286	91637	CSC08A-01-473G	1	
Z	6		RES,CERM,SIP,6 PIN,5 RES,4.7K,+-2%	494690	91637	CSC06A-01-472G	1	

An * in 'S' column indicates a static-sensitive part.

NOTES:

1. Part number 825547 is a complete set of 5 programmed ICs.

Table 9A-10. A2 Alarm Annunciator PCA
(See Figure 9A-15.)

REFERENCE DESIGNATOR -A>-NUMERICS---->			S--------------DESCRIPTION------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
C	1		CAP,TA,10UF,+-20%,20V	330662	56289	196D106X0020KA1	1		
C	3,	7- 11	CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE112SU224MSOV	6		
C	4		CAP,AL,1000UF,+50-20%,35V	641217	57640	SM/VB	1		
C	5		CAP,CER,0.01UF,+80-20%,25V,Y5U	335786	72982	5835-000Y5-U103Z	1		
C	6		CAP,TA,47UF,+-20%,20V	348516	56289	196D476X0020TE4	1		
CR	2,	3	* DIODE,SI,BV= 50.0V,IO=150MA,SELCTD VF	234468	07910	TD9039	2		
J	77		HEADER,1 ROW,0.100 CTR,6 PIN	758003	89536	758003	1		
K	1,	2	RELAY,ARMATURE,2 FORM C,5V	733063	89536	733063	2	1	
R	1-	3	RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	3		
R	5		RES,MF,56.2K,+-1%,0.125W,100PPM	271346	91637	CMF555622F	1	1	
U	1		* IC,CMOS,TIMER	742254	89536	742254	1	1	
U	2,	5	* IC,LSTTL,DUAL D F/F,+EDG TRG,W/CLR	393124	01295	SN74LS74N	2		
U	3		* IC,LSTTL,QUAD 2 INPUT NAND GATE	393033	01295	SN74LS00N	1	1	
U	4		* IC,LSTTL,TRIPLE 3 INPUT NAND GATE	393074	01295	SN74LS10N	1	1	
U	6		* IC,TTL,DUAL NAND DRVR W/OPEN COLLECT	329706	01295	SN75452P	1	1	
XK	1,	2	SOCKET,IC,16 PIN	276535	91506	316-AG39D	2		

An * in 'S' column indicates a static-sensitive part.
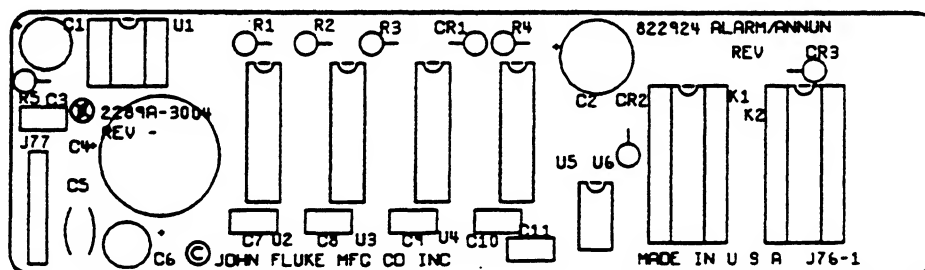
NOTES: UNLESS OTHERWISE SPECIFIED.
1. SEE DRAWING 2289A-1004 FOR SCHEMATIC.
2. SEE DRAWING 2289A-4004 FOR ASSEMBLY.

2289A-1604

Figure 9A-13. A2 Alarm Annunciator PCA

CONTENTS

APPENDIX A
SPECIFICATIONS

MAINFRAME SPECIFICATIONS

General Specifications

Channel Capacity
    Mainframe .... 100 Analog or 120 Digital
    System .... 1500 maximum (1000 for -201
        Scan Alarm Option)

Memory .... Nonvolatile, with 15-day
    typical, 10-day minimum
    battery backup

Scanning Speed (analog inputs)
    Dependent on system configuration and programming

    Maximum System Scanning Speed in Channels per Second

A/D Converters in System	Direct Voltage Readings
1	16
2	30
3	42
4	50

Power
    AC .... 90-132V, 180-264V, 47-440 Hz
    Dissipation .... <40W

Temperature
    Operating .... 0 to 50°C
    Storage .... -40 to 70°C

Humidity (non-condensing)
    0 to 25 C .... <95%
    25 to 40 C .... <75%
    40 to 50 C .... <45%

Weight .... 8.5 kg (19 lbs)
    Without options

Dimensions .... Height   Width   Depth
    23.8 cm x 43.9 cm x 35.9 cm
    9.35 in x 17.30 in x 14.13 in

Altitude
    Operating .... 3050m (10,000 feet)
    Non-operating .... 12,200m (40,000 feet)

Shock and Vibration .... Meets MIL-T-28800C Class 5,
    Style F Standard

EMI and RFI Emissions .... Tested to FCC Part 15, Subpart J, Class A; VDE 0871, Class B.

Communications Interface Specifications

Type .... Asynchronous, either RS-232-C or RS-422

Connector .... 25-pin male; pinout depends on S1 setting: RS-232 or RS-422

RS-232-C Pinout (S1 in RS-232-C Position)

PIN NUMBER   SIGNAL

(1) .... Shield
(2) .... Transmitted Data
(3) .... Received Data
(4) .... Request to Send
(5) .... Clear to Send
(6) .... Data Set Ready
(7) .... Signal Ground
(8) .... Received Line Signal Detector
(12) .... Secondary Received Line Signal Detector
(20) .... Data Terminal Ready
(22) .... Ring Indicator

Required RS-232-C
Signals .... Transmit Data, Receive Data, Signal Ground. All other lines are passively asserted true. Instrument will operate if these other lines are left disconnected.

RS-232 Modem Control .... Full duplex

RS-422 Pinout (S1 in RS-422 Position)

PIN NUMBER   SIGNAL

(1) .... Shield

(7) .... Common

(9) .... Transmit +
(10)....................... Transmit -

(14) .... Receive +
(15) .... Receive -

)

NOTE

RS-232-C signals are present on their associated pins even when S1 is set for RS-422 operation, but they are not used when configured for RS-422.

Baud Rate .... Switch-selectable: 110, 300, 600, 1200, 2400, 4800, 9600, 19200

ASCII Format .... 7 or 8 bit, 1 or 2 stop bits. Switch-selectable

Parity .... Odd, even, or none. Switch-selectable

Multi-drop Capability .... Available via RS-422. Ten mainframes can be addressed by a host through a single RS-422 port. Address is switch-selectable.

OPTION SPECIFICATIONS

-160 AC Voltage Input Connector Specifications

```
Channels ......................... 10 ac, 10 dc
Terminals ........................ 40 (2 per channel)
AC Voltage
    Range ........................ 5V to 250V rms
    Resolution ................... 0.1V ac
    Maximum Input ................ 250V rms between two
                                   terminals
    Frequency Range .............. 45 Hz to 450 Hz
    Accuracy ..................... See System Accuracy
                                   Specifications
    Conversion Method ............ 1/2 wave, average
                                   responding, calibrated to
                                   indicate the rms value of
                                   a sine wave.
DC Voltage
    Ranges and Accuracy .......... Determined by the
                                   option -162.
    Maximum Input ................ 250V dc between any two
                                   terminals
Maximum Common Mode Voltage ...... 250V dc between terminals
                                   or between a terminal
                                   and ground.
Compatibility .................... Attaches to the
                                   Thermocouple/DC Volts
                                   Scanner (option -162).
Temperature
    Operating .................... -20 to 70°C
    Storage ...................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C ................... <= 95%
    25 to 40°C ................... <= 75%
    40 to 50°C ................... <= 45%
    50 to 70°C ................... <= 40%
Altitude
    Non-Operating ................ 40,000 feet
    Operating .................... 10,000 feet
Shock and Vibration .............. Meets MIL-T-28800C,
                                   Class 5 Standards
```

-161 High Performance A/D Converter

-161 High Performance A/D Converter Specifications

Dynamic Range (internal) .... $\pm$131,071 counts at 50 Hz
$\pm$109,226 counts at 60 Hz

Common Mode Rejection .... 170 dB at 50 Hz $\pm$0.1%
(with 100-ohm imbalance) 170 dB at 60 Hz $\pm$0.1%
160 dB at dc

Normal Mode Rejection .... 60 dB at 50 Hz $\pm$0.1%
or 60 Hz $\pm$0.1%

Isolation .... 250V dc or ac rms between
-161 and any other
module.

Measurement Method .... Dual slope, integrating
over 1 line cycle

Zero Stability .... Automatic zero

Ranges, Resolution, Accuracy ... Determined by Scanner (see
-162 and -163 and application.
See Accuracy Specifications:
    Temperature Measurement
        Using Thermocouples
    Temperature Measurement
        Using RTDs
    DC Voltage Measurement
    AC Voltage Measurement
    DC Current Measurement
    Resistance Measurement
    Strain Measurement

Temperature
    Operating .... -20 to 70°C
    Storage .... -55 to 75°C

Relative Humidity (without condensation)
    Below 25°C .... <= 95%
    25 to 40°C .... <= 75%
    40 to 50°C .... <= 45%
    50 to 70°C .... <= 40%

Altitude
    Non-Operating .... 40,000 feet
    Operating .... 10,000 feet

Shock and Vibration .... Meets MIL-T-28800C,
Class 5 Standards

-162 Thermocouple/DC Volts Scanner Specifications

```
Channels ....................... 20
Poles per Channel .............. 3 (HI, LO, SHIELD)
Input Impedance
    64-mV and 512-mV Ranges .... >200 megohm in parallel with
                                 5600 pF
    8V and 64V Ranges .......... 10 megohm
Voltage Offset (max) ........... 1 uV
```

Ranges and Displayed Resolution	60 Hertz	50 Hertz
64 mV Range	0.6 uV	0.5 uV
512 mV Range	5.0 uV	4.2 uV
8V Range	73 uV	61 uV
64V Range	0.6 mV	0.5 mV

```
Accuracy ....................... Determined by application.
                                 See Accuracy Specifications:
                                     Temperature Measurement
                                         Using Thermocouples
                                     DC Voltage Measurement
                                     AC Voltage Measurement
                                     DC Current Measurement
                                     Strain Measurement
Zero Stability ................. Automatic Zero
Input Isolation ................ 250V dc or ac rms between
                                 any two channels or any
                                 channel and ground
Overload without Damage ........ 250V dc or 250V ac rms
Common Mode Voltage (max) ...... 250V dc or ac rms between
                                 any 2 terminals or a
                                 terminal and ground
Common Mode Rejection .......... 170 dB at 50 Hz ±0.1%
    (with 100 ohm imbalance)     170 dB at 60 Hz ±0.1%
                                 160 dB at dc
Normal Mode Rejection .......... 60 dB at 50 Hz ±0.1%
                                 or 60 Hz ±0.1%

Temperature
    Operating .................. -20 to 70°C
    Storage .................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C ................. <= 95%
    25 to 40°C ................. <= 75%
    40 to 50°C ................. <= 45%
    50 to 70°C ................. <= 40%
Altitude
    Non-Operating .............. 40,000 feet
    Operating .................. 10,000 feet
Shock and Vibration ............ Meets MIL-T-28800C,
                                 Class 5 Standards
```

-163 RTD/Resistance Scanner Specifications

```
Channels ...................... 20
Poles per Channel ............. 4 (HI EXCITATION, HI, LO,
                                 LO EXCITATION)
Common Return Poles ........... 2 (LO COM for channels
                                 0-9, LO COM for channels
                                 10-19)
Measurement Modes (3) ......... 4-Wire (4W) (no reed
                                 resistances in measurement
                                 path).
                                 3-Wire Accurate (3WA) (no
                                 reed resistances in
                                 measurement path. Channels
                                 in a decade share a common
                                 return).
                                 3-Wire Isolated (3WCM) (one
                                 reed resistance in
                                 measurement path).
Measurement Mode Selection .... 2 jumpers select scanner
                                 measurement mode
Current Sources ............... 2 (1 mA, 32 uA)
Resistance Ranges, Resolution, and Excitation
    Range ..................... 256 ohm
        Internal Resolution ... 2.4, 2.0 milliohm (60, 50 Hz)
        Excitation ............ 1 mA
    Range ..................... 2048 ohm
        Internal Resolution ... 19, 16 milliohm (60, 50 Hz)
        Excitation ............ 1 mA
    Range ..................... 64 kilohm
        Internal Resolution ... 0.6, 0.5 ohm (60, 50 Hz.)
        Excitation ............ 32 uA
Accuracy ...................... Determined by application
                                 See Accuracy Specifications:
                                     Temperature Measurement
                                         Using RTDs
                                     Resistance Measurement
Zero Stability ................ Automatic zero

Input Channel Isolation
    4-Wire (4W) ............... 250V dc or ac rms between
                                 any two channels
    3-Wire Accurate (3WA) ..... 250V dc or ac rms between
                                 decades of channels
    3-Wire Isolated (3WCM) .... 250V dc or ac rms between
                                 any two channels
Overload without Damage ....... 30V dc or 24V ac rms
                                 between any two terminals
                                 of a channel
```

Common Mode Isolation .... 250V dc or ac rms between
scanners,
250V dc or ac rms between
decades of channels,
250V dc or ac rms between
channels within a decade
for 4-Wire (4W) and 3-Wire
isolated (3WCM) measurement
modes,
30V dc or 24V ac rms
between any terminals in
the same decade except
between LO COMs for the
3-Wire Accurate (3WA)
measurement mode

Temperature
    Operating .... -20 to 70°C
    Storage .... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C .... <= 95%
    25 to 40°C .... <= 75%
    40 to 50°C .... <= 45%
    50 to 70°C .... <= 40%
Altitude
    Non-Operating .... 40,000 feet
    Operating .... 10,000 feet
Shock and Vibration .... Meets MIL-T-28800C,
Class 5 Standards

-164 Transducer Excitation Module Specifications

Outputs .... 5 constant current sources
1 constant voltage source

Channels of Excitation .... 20, selectable in groups
of 4 for either voltage or
current outputs

Common Mode Voltage .... No user-applied common
mode voltage allowed. All
sensors must be isolated.

4-Wire Resistance Measurements .. 5 constant current
sources. Each source
excites up to 4 transducers.

3-Wire Resistance and
Strain Gauge Measurements .... Any combination of 1/4,
1/2, and/or Full Bridge
strain gauges or 3-wire
RTDs with voltage
excitation and
user-supplied bridge
completion resistors.

Current Excitation
    Excitation Current .... 1.0 mA
    Accuracy
      Initial Setting 0.005%
      Temperature 15 to 35°C 0.015%
        Time since calibration .. 90 days
      Temperature 15 to 35°C 0.030%
        Time since calibration .. 1 year
      Temperature -20 to 70°C ... 0.050%
        Time since calibration .. 1 year
    Temperature Coefficient
      (<15 or >35°C) .... 10 ppm per $^{\circ}$C
    Maximum Compliance Voltage .. 0.6V

Voltage Excitation
    Excitation Voltage .... switch selectable to 2.0V
dc or 4.0V dc
    2 Volt Accuracy
      Initial Setting 0.0025%
      Temperature 15 to 35°C 0.03%
        Time since calibration .. 90 days
      Temperature 15 to 35°C 0.04%
        Time since calibration .. 1 year
      Temperature -20 to 70°C ... 0.05%
        Time since calibration .. 1 year
    4 Volt Accuracy
      Initial Setting 0.0035%
      Temperature 15 to 35°C 0.015%
        Time since calibration .. 90 days
      Temperature 15 to 35°C 0.030%
        Time since calibration .. 1 year

```
         Temperature -20 to 70°C ... 0.05%
           Time since calibration .. 1 year
         Temperature Coefficient
           (<15 or >35°C) .......... 7 ppm per °C
         Maximum Current ............. 250 mA
Accuracy ....................... Determined by application.
                                See the Accuracy
                                Specifications in this Appendix.

Temperature
     Operating ................... -20 to 70°C
     Storage ..................... -55 to 75°C
Relative Humidity (without condensation)
     Below 25°C .................. <= 95%
     25 to 40°C .................. <= 75%
     40 to 50°C .................. <= 45%
     50 to 70°C .................. <= 40%
Altitude
     Non-Operating ............... 40,000 feet
     Operating ................... 10,000 feet
Shock and Vibration ............. Meets MIL-T-28800C,
                                Class 5 Standards
```

-167 Counter/Totalizer Specifications

```
Channels ..................... 6
Functions .................... Event counting and frequency
                               measurement selectable by
                               channel pairs
Timebase
      Frequency ............... 10 MHz
      Accuracy ................ ±0.01%
Input Signals
      Types.................... TTL, CMOS, contacts, and
                               analog waveforms
      Minimum Pulse Width ..... 1.25 microseconds
      Minimum Signal Amplitude.. 175 mV rms
                               0.5V p-p sine wave
                               0.35V p-p square wave
      Maximum Signal Amplitude.. ± 15V dc or ac peak
Adjustments .................. Signal threshold, deadband,
                               and contact debounce
Frequency Measurement
      Minimum Frequency ....... 2 Hz
      Maximum Frequency ....... 400 kHz
      Accuracy ................ Timebase accuracy ± 1 digit

Totalizing Measurement
      Maximum Counts .......... 8,388,607
      Counting Rate ........... dc to 400 kHz
Isolation .................... 30V dc or ac rms between
                               any terminal and ground.
                               No isolation between
                               channels.
Power Consumption ............ 4.0 watts maximum

Temperature
      Operating ............... -20 to 70 degrees Celsius
      Storage ................. -55 to 75 degrees Celsius
Relative Humidity (without condensation)
      Below 25 degrees Celsius ....... <= 95%
      25 to 40 degrees Celsius ....... <= 75%
      40 to 50 degrees Celsius ....... <= 45%
      50 to 70 degrees Celsius ....... <= 40%

Altitude
      Non-Operating ........... 40,000 feet
      Operating ............... 10,000 feet
Shock and Vibration ......... Meets MIL-T-28800C, Class 5
                               Standards
```

-168 Digital I/O Specifications

Isolation	30V dc or ac rms between any terminal and ground.
Input Line	Pulled up to +5V through a 47 kilohm resistor.
Input Handshake Line Circuit	Pulled up to +5V through a 47 kilohm resistor.

Inputs
    Channels .... 20 single bit,
                            or one 5 BCD digit word,
                            or one 17-bit binary word
    Type .... Low Power Schottky TTL
    Maximum Input Voltage 6V
Outputs
    Channels .... 20 single bit
    Type .... Open-collector, diode clamped, NPN transistors
    Output Drive .... 100 mA with 1V drop
    Maximum Voltage on Output ... 30V dc
Power Consumption .... 1.5 watts maximum
Temperature
    Operating .... -20 to 70°C
    Storage .... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C .... <= 95%
    25 to 40°C .... <= 75%
    40 to 50°C .... <= 45%
    50 to 70°C .... <= 40%
Altitude
    Non-Operating .... 40,000 feet
    Operating .... 10,000 feet
Shock and Vibration .... Meets MIL-T-28800C, Class 5 Standards

-169 Status Output Connector

-169 Status Output Connector Specifications

```
Outputs ......................... 20
Terminals ....................... 2 per channel
Compatibility ................... Connects to Digital I/O
                                  (option 168)
Temperature
    Operating ................... -20 to 70°C
    Storage ..................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C .................. <= 95%
    25 to 40°C .................. <= 75%
    40 to 50°C .................. <= 45%
    50 to 70°C .................. <= 40%
Altitude
    Non-Operating ............... 40,000 feet
    Operating ................... 10,000 feet
Shock and Vibration ............. Meets MIL-T-28800C,
                                  Class 5 Standards
```

-170 Analog Output Specifications

```
Channels ........................ 4
Terminals ....................... 5 per channel
Accuracy ........................ +0.1% of range
    Time since Calibration ...... 90 days
    Operating Temperature ....... 15 to 35°
Accuracy ........................ +0.2% of range
    Time since Calibration ...... 1 year
    Operating Temperature ....... 15 to 35°C
Accuracy ........................ +0.4% of range
    Time since Calibration ...... 1 year
    Operating Temperature ....... -20 to 70°C
Noise ........................... < 0.02% of range in a
                                  10-kHz bandwidth
Voltage Outputs
    Ranges ...................... -5 to +5V, 0 to +10V
    Resolution .................. 2.5 mV/count
    Maximum Current ............. 2 mA
    Capacitive Load ............. 10,000 pF maximum
    Output Protection ........... short-circuit protected
Current Output
    Range ....................... 4 to 20 mA
    Resolution .................. 4 uA
    Maximum Compliance Voltage .. 10V
Maximum External Voltage ........ +24V
Isolation ....................... 30V dc or ac rms between
                                  any terminal and ground.
                                  No isolation between
                                  channels.
                                  Current outputs share a
                                  common return.
Power Consumption ............... 4.1 watts maximum
Temperature
    Operating ................... -20 to 70°
    Storage ..................... -55 to 75°
Relative Humidity (without condensation)
    Below 25° ................... <= 95%
    25 to 40° ................... <= 75%
    40 to 50° ................... <= 45%
    50 to 70° ................... <= 40%
Altitude
    Non-Operating ............... 40,000 feet
    Operating ................... 10,000 feet
Shock and Vibration ............. Meets MIL-T-28800C,
                                  Class 5 Standards
```

-171 Current Input Connector

-171 Current Input Connector Specifications

```
Channels ......................... 20
Terminals ........................ 2 per channel
Shunt Resistor ................... 8 ohms ±0.02 ohm
Measurement Range ................ 64 mA
Overload without Damage .......... 250 mA
Common Mode Voltage .............. 250V dc or ac rms between
                                   any two channels or
                                   between a channel and
                                   ground.
Accuracy ......................... 0.25% Input ±4 uA
     Time since A/D Calibration .. 90 days
Resolution ....................... 1 uA
Compatibility .................... Attaches to
                                   -162 Thermocouple/DC Volts
                                   Scanner.
Temperature
     Operating ................... -20 to 70°C
     Storage ..................... -55 to 75°C
Relative Humidity (without condensation)
     Below 25°C .................. <= 95%
     25 to 40°C .................. <= 75%
     40 to 50°C .................. <= 45%
     50 to 70°C .................. <= 40%
Altitude
     Non-Operating ............... 40,000 feet
     Operating ................... 10,000 feet
Shock and Vibration .............. Meets MIL-T-28800C,
                                   Class 5 Standards
```

-174 Transducer Excitation Connector Specifications

```
Channels ........................ 20
Terminals ....................... 5 per channel
Programming ..................... 5 jumpers select voltage
                                  or current excitation on
                                  5 groups of 4 channels.
Compatibility ................... Attaches to -164 Transducer
                                  Excitation Module
Temperature
    Operating ................... -20 to 70°C
    Storage ..................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C .................. <= 95%
    25 to 40°C .................. <= 75%
    40 to 50°C .................. <= 45%
    50 to 70°C .................. <= 40%
Altitude
    Non-Operating ............... 40,000 feet
    Operating ................... 10,000 feet
Shock and Vibration ............. Meets MIL-T-28800C,
                                  Class 5 Standards
```

-175 Isothermal Input Connector

-175 Isothermal Input Connector Specifications

```
    Channels ........................ 20
    Terminals ....................... 60 (HI, LO, SHIELD per
                                      channel)
    Maximum Voltage Rating .......... 250V dc or ac rms from any
                                      terminal to any other
                                      terminal or ground.
Temperature
    Operating ................... -20 to 70°C
    Storage ..................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C .................. <= 95%
    25 to 40°C .................. <= 75%
    40 to 50°C .................. <= 45%
    50 to 70°C .................. <= 40%
Altitude
    Non-Operating ............... 40,000 feet
    Operating ................... 10,000 feet
Shock and Vibration ............. Meets MIL-T-28800C,
                                  Class 5 Standards
```

-176 Voltage Input Connector Specifications

```
Channels ........................ 20
Terminals ....................... 60 (HI, LO, SHIELD per
                                    channel)
Maximum Voltage Rating .......... 250V dc or ac rms from any
                          -         terminal to any other
                                    terminal or ground.
Temperature
    Operating ................... -20 to 70°C
    Storage ..................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C .................. <= 95%
    25 to 40°C .................. <= 75%
    40 to 50°C .................. <= 45%
    50 to 70°C .................. <= 40%
Altitude
    Non-Operating ............... 40,000 feet
    Operating ................... 10,000 feet
Shock and Vibration ............. Meets MIL-T-28800C,
                                    Class 5 Standards
```

-177 RTD/Resistance Input Connector Specifications

```
Channels ........................ 20
Terminals ....................... 100
          (HI EXC, HI, LO, LO EXC, and LO COM per Channel)

Maximum Wire Size .............. 16 AWG
Maximum Voltage Rating and
Mating RTD/Resistance Scanner Mode
     163 Measurement Mode ........ 4-wire (4W)
          Ratings ............... 250V dc or ac rms between
                                  two channels or a channel
                                  and ground; 30V or 24V ac
                                  rms between channel terminals

     163 Measurement Mode ........ 3-wire Accurate (3WA)
          Ratings ............... 250V dc or ac rms between
                                  channels in different
                                  decades or between channels
                                  in a decade and ground;
                                  30V dc or 24V ac rms
                                  between terminals within
                                  a decade except between
                                  LO COMs. (LO COMs of
                                  channels in a decade are
                                  connected internally.)

     163 Measurement Mode ........ 3-Wire Isolated (3WCM)
          Ratings ............... Same as for 4-Wire
Compatibility ................... Attaches to RTD/Resistance
                                  Scanner (Option 163)
Temperature
     Operating ................... -20 to 70°C
     Storage ..................... -55 to 75°C
Relative Humidity (without condensation)
     Below 25   .................. <= 95%
     25 to 40   .................. <= 75%
     40 to 50   .................. <= 45%
     50 to 70   .................. <= 40%
Altitude
     Non-Operating ............... 40,000 feet
     Operating ................... 10,000 feet
     Shock and Vibration ......... Meets Mil-T-28800C, Class
                                   5 standards
```

-179 Digital/Status Input Connector Specifications

```
Channels .......................... 20 single bit, or
                                     one 5 BCD digit word, or
                                     one 17-bit binary word
Terminals ......................... 72
Maximum Input Voltage ............ 6V dc
Isolation ......................... 30V dc or ac rms between
                                     any terminal and ground.
Compatibility .................... Attaches to Digital I/O
                                     (option 168)
Temperature
    Operating .................... -20 to 70°C
    Storage ...................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C ................... <= 95%
    25 to 40°C ................... <= 75%
    40 to 50°C ................... <= 45%
    50 to 70°C ................... <= 40%
Altitude
    Non-Operating ................ 40,000 feet
    Operating .................... 10,000 feet
Shock and Vibration ............. Meets MIL-T-28800C,
                                     Class 5 Standards
```

-201 Scan/Alarm Option

Printer Port Connector - 25 pin

PIN NUMBER	SIGNAL
1	Shield
2	Transmitted Data
3	Received Data
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Signal Ground

Alarm Annunciator Terminator Strip

TERMINAL NUMBER	FUNCTION
8	Connect to Normally Closed Contact of Alarm Acknowledgement Push Button.
7	Connect to Normally Open Contact of the Alarm Acknowledgement Push Button.
6	Connect to Common Contact of the Alarm Acknowledgement Push Button
5	No Connection
2,4	Normally Open Contacts for Visual Alarm Light (Max 1A at 120V ac or 30V dc)
1,3	Normally Open Contacts for Audible Alarm. (Max 1A at 120V ac or 30V dc)

ACCURACY SPECIFICATIONS

Temperature Measurement Using Thermocouples

Hardware Used ...... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-175 Isothermal Input Connector

Accuracy In $\pm^\circ$C

Thermocouple Type (Sensor Temperature Range) Sensor Temperature ($^\circ$C)	Time Since A/D Calibration (Operating Temperature in $^\circ$C)		
	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
J NBS (-200 to 760°C)			
-200 to -100	0.45	0.5	1.6
-100 to +200	0.35	0.4	0.9
+200 to +760	0.45	0.5	0.75
J DIN (-200 to 760°C)			
-200 to -100	0.45	0.5	1.6
-100 to +200	0.35	0.4	0.9
+200 to +900	0.45	0.5	0.75
K NBS (-225 to 1350°C)			
-225 to -100	0.45	0.5	1.9
-100 to +200	0.35	0.4	1.0
+200 to 1350	0.5	0.6	1.25
T NBS (-230 to 400°C)			
-230 to -100	0.45	0.5	1.9
-100 to +200	0.35	0.4	1.0
+200 to +400	0.45	0.5	0.6
T DIN (-200 to 600°C)			
-230 to -100	0.45	0.5	1.9
-100 to +200	0.35	0.4	1.0
+200 to +600	0.45	0.5	1.25
E NBS (-250 to 838°C)			
-250 to -100	0.45	0.5	1.5
-100 to +250	0.35	0.4	0.9
+250 to +838	0.45	0.6	0.85
R NBS (0 to 1767°C)			
0 to +200	1.15	1.35	2.2
+200 to +1767	0.95	1.15	1.6

Accuracy In $\pm$°C

Thermocouple Type (Sensor Temperature Range) Sensor Temperature (°C)	Time Since A/D Calibration (Operating Temperature in °C)		
	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
S NBS (0 to 1767°C)			
0 to +200	1.15	1.35	2.2
+200 to +1767	0.95	1.15	1.6
B NBS (200 to 1820°C)			
+200 to +500	1.05	1.25	10.0
+500 to +1820	1.05	1.25	3.8
N NBS (-200 to 400°C) (For 28-gauge thermocouple wire)			
-200 to -100	0.45	0.5	1.9
-100 to +200	0.35	0.4	1.0
+200 to +400	0.5	0.6	1.25
C HOS (0 to 2315°C)			
0 to +2315	0.85	1.05	1.8

Temperature Measurement Using RTDs

```
Hardware Used ..... -161 High Performance A/D
                    -163 RTD/Resistance Scanner
                    -177 RTD/Resistance Input Connector
```

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (Sensor Temperature Range) Sensor Temperature ($^{\circ}$C)	90 Days Since A/D Calibration 18 to 28°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min		
	Accuracy	Resolution	Repeatability

Platinum 385 DIN, High Resolution, 4-Wire (4W), and
(-200 to 425°C)

	Accuracy	Resolution	Repeatability
-200 to 150	0.09°C*	0.006°C	0.03°C
150 to 425	0.13°C	0.006°C	0.04°C

Platinum 385 DIN, High Temperature, 4-Wire (4W), and
(-200°C to probe limit)

	Accuracy	Resolution	Repeatability
-200 to 600	0.25°C	0.05°C	0.14°C

10-Ohm Copper, 4-Wire (4W)

	Accuracy	Resolution	Repeatability
(full range)	0.28°C	0.06°C	0.16°C

Platinum 385 DIN, 3-Wire Accurate (3WA)

+0.007°C** +0.001°C**

10-Ohm Copper, 3-Wire Accurate (3WA)

+0.065°C** +0.008°C**

Platinum 385 DIN, 3-Wire Isolated (3WCM)

+1.97°C*** +1.97°C***

10-Ohm Copper, 3-Wire Isolated (3WCM)

+18.2°C* +18.2°C*

NOTES:

* An ice-point initialization allows 385 DIN RTDs to have an accuracy of 0.05°C + probe conformity.
** Add $^{\circ}$C per ohm lead resistance to 4W specifications.
*** Add $^{\circ}$C to 3WA specs.

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (Sensor Temperature Range) Sensor Temperature (°C)	90 Days Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10 min		
	Accuracy	Resolution	Repeatability

Platinum 385 DIN, High Resolution, 4-Wire (4W), and
(-200 to 425°C)

-200 to 150	0.10°C	0.006°C	0.04°C
150 to 425	0.15°C	0.006°C	0.04°C

Platinum 385 DIN, High Temperature, 4-Wire (4W), and
(-200°C to probe limit)

-200 to 600	0.27°C	0.05°C	0.16°C

10-Ohm Copper, 4-Wire (4W)

(full range)	0.3°C	0.06°C	0.16°C

Platinum 385 DIN, 3-Wire Accurate (3WA)

+0.007°C*   +0.001°C*

10-Ohm Copper, 3-Wire Accurate (3WA)

+0.065°C*   +0.008°C*

Platinum 385 DIN, 3-Wire Isolated (3WCM)

+1.97°C**   +1.97°C**

10-Ohm Copper, 3-Wire Isolated (3WCM)

+18.2°C**   +18.2°C**

NOTES:

    * Add °C per ohm lead resistance to 4W specs
  ** Add °C to 3WA specs

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (Sensor Temperature Range) Sensor Temperature (^{O}C)	1 Year Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1^{O}C / 10min	
	Accuracy	Resolution

Platinum 385 DIN, High Resolution, 4-Wire (4W), and
(-200 to 425°C)

-200 to 150	0.11^{O}C	0.006^{O}C
150 to 425	0.16^{O}C	0.006^{O}C

Platinum 385 DIN, High Temperature, 4-Wire (4W), and
(-200°C to probe limit)

-200 to 600	0.28^{O}C	0.05^{O}C

10-Ohm Copper, 4-Wire (4W)

(full range)	0.3^{O}C	0.06^{O}C

Platinum 385 DIN, 3-Wire Accurate (3WA)
(full range)   Add 0.008^{O}C
                      per ohm lead resistance
                      to 4W specs

10-Ohm Copper, 3-Wire Accurate (3WA)
(full range)   Add 0.073^{O}C
                      per ohm lead resistance
                      to 4W specs

Platinum 385 DIN, 3-Wire Isolated (3WCM)
(full range)   Add 2.53^{O}C to 3WA specs

10-Ohm Copper, 3-Wire Isolated (3WCM)
(full range)   Add 23.4^{O}C to 3WA specs

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature ($^{\circ}$C)	1 Year Since A/D Calibration −20 to 70°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min	
	Accuracy	Resolution

Platinum 385 DIN, High Resolution, 4-Wire (4W), and
(-200 to 425°C)

-200 to 150	0.19°C	0.006°C
150 to 425	0.29°C	0.006°C

Platinum 385 DIN, High Temperature, 4-Wire (4W), and
(-200°C to probe limit)

-200 to 600	0.44°C	0.05°C

10-Ohm Copper, 4-Wire (4W)

(full range)	0.4°C	0.06°C

Platinum 385 DIN, 3-Wire Accurate (3WA)
(full range)   Add 0.010°C
              per ohm lead resistance
              to 4W specs

10-Ohm Copper, 3-Wire Accurate (3WA)
(full range)   Add 0.096°C
              per ohm lead resistance
              to 4W specs

Platinum 385 DIN, 3-Wire Isolated (3WCM)
(full range)   Add 2.53°C to 3WA specs

10-Ohm Copper, 3-Wire Isolated (3WCM)
(full range)   Add 23.4°C to 3WA specs

Temperature Measurement Using RTDs

Hardware Used .... -161 High Performance A/D
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
·(with current excitation selected)
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Performance

RTD Type and Scanner Range (sensor temperature range) Sensor Temperature (^{o}C)	90 Days Since Calibration 15 to 35°C Operating Temperature		
	Accuracy	Resolution	Repeatability
Platinum 385 DIN (-200°C to probe limit) -200 to 600	0.2^{o}C	0.013^{o}C	0.08^{o}C
10-Ohm Copper (full range)	1.0^{o}C	0.1^{o}C	0.2^{o}C

DC Voltage Measurement Accuracy

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Accuracy

Range	Internal Resolution (microvolts)		Time Since A/D Calibration (Operating Temperature in $^{\circ}$C) ($\pm$ % Input $\pm$ microvolts)		
	60 Hz	50 Hz	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
$\pm$64 mV	0.6	0.5	0.005% + 7.0	0.01% + 8.0	0.03% + 9.0
$\pm$512 mV	5.0	4.2	0.005% + 30	0.01% + 40	0.03% + 50
$\pm$8V	73	61	0.005% + 700	0.01% + 800	0.03% + 900
$\pm$64V	600	500	0.009% + 3mV	0.02% + 4mV	0.05% + 5mV

AC Voltage Measurement Accuracy

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-160 AC Voltage Input Connector

Performance

Range and Frequencies	90 Days Since A/D Calibration 15 to 35°C Operating Temperature	
	Resolution	Accuracy
5V to 250V ac rms, 45 Hz to 450 Hz	0.1V	$\pm$1% Input $\pm$.1V

DC Current Measurement Accuracy

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-171 Current Input Connector

Performance

Range	90 Days Since A/D Calibration 15 to 35°C Operating Temperature	
	Resolution	Accuracy
±64 mA	0.6 uA	±.25% ±4 uA

Resistance Measurement Accuracy

Hardware Used ...... -161 High Performance A/D
-163 RTD/Resistance Scanner
-177 RTD/Resistance Input Connector

Performance

Scanner Range and Measurement Mode	90 Days Since A/D Calibration 18 to 28°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min		
	(mohm)	(±% Input ± mohm)	
	Resolution 60 Hz 50 Hz	Accuracy	Repeatability
256 ohm, 4-Wire (4W)			
	2.4 2.0	0.0142% + 5.7	0.0037% + 5.7
2048 ohm, 4-Wire (4W)			
	19 16	0.0137% + 38	0.0032% + 38
64 kilohm, 4-Wire (4W)			
	600 500	0.055% + 1.2 ohm	0.0040% + 1.2 ohm**
All, 3-Wire Accurate (3WA)			
	same as 4W	Add 2.4 mohm per ohm lead resistance to 4W specs	Add 0.2 mohm per ohm lead resistance to 4W specs
All, 3-Wire Isolated (3WCM)			
	same as 4W	Add 0.7 ohm per ohm lead resistance to 3WA specs	Add 0.7 ohm per ohm lead resistance to 3WA specs

** Humidity 15%RH less than listed for the -163 Scanner

Performance

Scanner Range and Measurement Mode	90 Days Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10 min			
	(mohm)		(±% Input ± mohm)	
	Resolution 60Hz 50Hz		Accuracy	Repeatability
256 ohm, 4-Wire (4W)	2.4	2.0	0.0170% + 5.7	0.0065% + 5.7
2048 ohm, 4-Wire (4W)	19	16	0.0165% + 38	0.0060% + 38
64 kilohm, 4-Wire (4W)	600	500	0.06% + 1.2 ohm	0.0075% + 1.2 ohm**
All, 3-Wire Accurate (3WA)	same as 4W		Add 2.5 mohm per ohm lead resistance to 4W specs	Add 0.3 mohm per ohm lead resistance to 4W specs
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.7 ohm per ohm lead resistance to 3WA specs	Add 0.7 ohm per ohm lead resistance to 3WA specs

**Humidity 15%RH less than listed for the -163 Scanner

Performance

Scanner Range and Measurement Mode	1 Year Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10 min	
	(milliohms) Resolution 60 Hz 50 Hz	Accuracy
256 ohm, 4-Wire (4W)	2.4 2.0	±.0175% Input ±5.7 mohm
2048 ohm, 4-Wire (4W)	19 16	±.0170% Input ±38 mohm
64 kilohm, 4-Wire (4W)	600 500	±.06% Input ±1.2 ohm
All, 3-Wire Accurate (3WA)	same as 4W	Add 2.8 mohm per ohm lead resistance to the 4W specifications
All, 3-Wire Isolated (3WCM)	same as 4W	Add 0.9 ohm to the 3WA specifications

Performance

Scanner Range and Measurement Mode	1 Year Since A/D Calibration -20 to 70°C Operating Temperature Temperature Shift dT/dt < 1°C / 10 min	
	(milliohms) Resolution 60 Hz 50 Hz	Accuracy
256 ohm, 4-Wire (4W)	2.4 2.0	±.0365% Input ±7 mohm
2048 ohm, 4-Wire (4W)	19 16	±.0360% Input ±38 mohm
64 kilohm, 4-Wire (4W)	600 500	±.23% Input ±1.2 ohm
All, 3-Wire Accurate (3WA)	same as 4W	Add 3.7 mohm per ohm lead resistance to the 4W specifications
All, 3-Wire Isolated (3WCM)	same as 4W	Add 0.9 ohm to the 3WA specifications

Resistance Measurement Accuracy

Hardware Used .... -161 High Performance A/D
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with current excitation selected)
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Performance

Range	90 Days Since Calibration 15 to 35°C Operating Temperature	
	(milliohms) Resolution 60 Hz 50 Hz	Accuracy
64 ohm	0.6 0.5	±.02% Input ±7 mohm
512 ohm	5.0 4.2	±.02% Input ±30 mohm

Strain Measurement Accuracy

```
Hardware Used ....  -161 High Performance A/D
                    -164 Transducer Excitation Module
                    -174 Transducer Excitation Connector
                         (with voltage excitation selected)
                    -162 Thermocouple/DC Volts Scanner
                    Choice of Connector:
                         -175 Isothermal Input
                         -176 Voltage Input
                         -160 AC Voltage Input
```

Performance

Gauge Type	90 Days Since Calibration 20 to 30°C Operating Temperature	
	Resolution	Accuracy
Full Bridge	0.25 uE	$\pm$.05% input $\pm$2 uE
1/2 Bridge	0.5 uE	$\pm$.05% input $\pm$13 uE
1/4 Bridge	0.5 uE	$\pm$.05% input $\pm$25 uE

APPENDIX B
FEDERAL SUPPLY CODES FOR MANUFACTURERS

Federal Supply Codes for Manufacturers

F00779
AMP, Inc.
Harrisburg, PA

01121
Allen-Bradley Co.
Milwaukee, WI

01295
Texas Instruments Inc.
Semiconductor Group
Dallas, TX

04222
AVX Kyocera Corp.
Myrtle Beach, SC

04713
Motorola Inc.
Semiconductor Products Sector
Phoenix, AZ

06383
Panduit Corp.
Tinley Park, IL

06665
Analog Devices
Formerly Precision Monolithics
Santa Clara, CA

07047
Ross Milton Co., The
Southampton, PA

0RYZ9
ITT Cannon
Santa Ana, CA

11961
Semicon Inc.
Burlington, MA

12014
Chicago Rivet & Machine Co.
Naperville, IL

17856
Siliconix Inc.
Santa Clara, CA

24355
Analog Devices Inc.
Norwood, MA

27014
National Semiconductor Corp.
Santa Clara, CA

27264
Molex Inc.
Lisle, IL

28213
Minnesota Mining & Mfg. Co.
Consumer Specialties Div. 3M
Center
Saint Paul, MN

28480
Hewlett-Packard Co.
Corporate HQ
Palo Alto, CA

33297
NEC Electronics USA Inc.
Electronic Arrays Inc. Div.
Mountain View, CA

34371
Harris Corp.
Semiconductor Sector
Military & Aerospace Div.
Melbourne, FL

44648
Samsung Semiconductor Inc.
San Clara, CA

46384
Penn Engineering & Mfg. Corp.
Danboro, PA

47379
ISOCOM
Campbell, CA

51406
Murata Erie, No. America Inc.
Symrna, GA

55224
SMK Electronics
Placentia, CA

55464
Central Semiconductor Corp.
Div. of Central State Industries, Inc.
Hauppauge, NY

55566
RAF Electronic Hardware Inc.
Seymour, CT

56289
Sprague Electric Co.
Nashua, NH

57053
Gates Energy Products
Denver, CO

59124
KOA Speer Electronics Inc.
Bradford, PA
60705
Cera-Mite Corp.
Grafton, WI

61394
SEEQ Technology Inc.
San Jose, CA

61429
Fox Electronics
Fort Myers, FL

61852
Computer Products Inc.
Boschert Div.
Fremont, CA

62643
United Chemi-con Inc.
Rosemont, IL

62786
Hitachi America Ltd.
Semiconductor & IC Div.
San Jose, CA

65940
Rohm Corp
Irvine, CA

68919
Inter-Technical Group Inc.,
The Wima Division
Elmsford, NY

6E570
North American Philips Corp.
Philips Components/Signetics
Sunnyvale, CA

70903
Cooper Belden Electronic Wire &
Cable
Geneva, IL

71400
Bussman - Now Magnum
Div. of Cooper Industries Inc.
St. Louis, MO

73734
Federal Screw Products Inc.
Chicago, IL

74594
Component Resources Inc.
Div of EPI International Corp.
Beaverton, OR

78553
Eaton Corp.
Engineered Fasteners Div.
Lakewood, OH

80294
Bourns Instruments Inc.
Riverside, CA

86928
Seastrom Mfg. Co. Inc.
Glendale, CA

87516
Standard Crystal
Kansas City, KS

88245
Winchester Electronics
Litton Systems-Useco Div.
Van Nuys, CA

89536
John Fluke Mfg. Co., Inc.
Everett, WA

91637
Dale Electronics Inc.
Columbus, NE

91802
Industrial Devices Inc.
Hackensack, NJ

91833
Keystone Electronics Corp.
Astoria, NY

95146
Augat Alcoswitch
North Andover, MA

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T&M Customer Support
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FAX: 32 2 525 6483

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FAX: 55 11 421-5032

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Casilla 16150
Santiago 9
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FAX: 56 2 232-2694

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Beijing 100004, PRC
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FAX: 86 1 512-3437

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FAX: 57 1 287-2248

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FAX: 45 32 883939

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2449 y Orellana
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TEL: 593 2 230283 or 520005
FAX: 593 2 561980

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el. Mohandessin
P.O. Box 242
Dokki Cairo
TEL: 20 2 490922

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SF-02631 ESPOO
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FAX: 358 0 529558

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Fluke France S.A.
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93002 Bobigny, Cedex
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FAX: 33 1 4942-8155

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Service VSF
Unternehmensbereich Elektronik
fuer Wissenschaft und Industrie
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FAX: 49 89 9605270

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10210 Athens
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FAX: 30 1 481-5180

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FAX: 852 834-1848

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TEL: 62 21 520 1122
FAX: 62 21 520 5189

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Tel Aviv 61580
TEL: 972-3-548-3737
FAX: 972-3-492190

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FAX: 39-39-203-6621

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FAX: 81 3 3434-0170

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203-1 Nonhyun-Dong
Kangnam-Ku
Seoul 135-010
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FAX: 82 02 546-1458

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Youngdong P.O. Box 1486
Kangnam-Ku
Seoul KOREA
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FAX: 82 2 553-0388

Malaysia
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P.O. Box 24
46700 Petaling Jaya
Selangor
TEL: 60 3 774-3422
FAX: 60 3 774-3414

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Industrial, S.A. De C.V.
Diagonal No. 27
Col. Del Valle
C.P. 03100, Mexico D.F.
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FAX: 52 5 687-8695

Mexicana De Electronica
Industrial, S.A.
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Centro C. San Martin Local 6
CD . Jaurez
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FAX: 16-23-02-35

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FAX: 31 40 644-260

Fluke Netherland B.V.
Technische Service Prof. Act.
Hurksestraat, 2C
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FAX: 51 14 27-1324

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P.O. Box 610, Greenhills
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FAX: 63 2 721-0491

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IE Division - T & M Department
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FAX: 351 1 410-7838 or 7986

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FAX: 27 11 889-3279

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FAX: 34 1 326-0668

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T&M Customer Support
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FAX: 46 8 667-4781

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Fluke Switzerland AG
T&M Customer Support
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FAX: 41 1 745-2240

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FAX: 886 2 502-9692

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FAX: 66 2 374-9965

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Inonu Caddesi 78/80
Posta Kutusu 504-Beyoglu
Instanbul
TEL: 90 1 143-5891

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FAX: 44 923-225067

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Casilla de Correo 1400
Libertad 2529
Montevideo
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FAX: 598 2 797-338

Venezuela
Coasin C.A.
Calle 9 Con Calle 4, Edif. Edinurbi
Apartado de Correos Nr-70.136
Los Ruices
Caracas 1070-A
TEL: 58 2 241-0309, 241-1248
FAX: 58 2 241-1939

APPENDIX D
MANUAL STATUS INFORMATION

Manual Status Information

The documentation in this manual applies to the pca revision level shown below.

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	—	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V
			X = The PCA revision levels documented in this manual.																				
A1	Motherboard PCA	799163							X														
A2	Computer Interface PCA	793562						X															
- 160	AC Voltage Input Connector PCA	728097			X																		
-161	High Performance A/D Converter PCA	642488																			X		
-162	Thermocouple/DC Volts Scanner PCA	642496													X								
-163	RTD Resistance Scanner PCA	642504								X													
-164	Transducer Excitation PCA	717587							X														
-167	Counter/Totalize PCA	642538					X																
-168	Digital I/O PCA	642546									X												
-169	Status Output Connector PCA	642553			X																		
-170	Analog Output PCA	728154						X															
-171	Current Input Connector PCA	642579			X																		
-174	Transducer Excitaton Connector PCA	716134		X																			
-175	Isothermal Input Connector PCA	642587									X												
-176	Voltage Input Connector PCA	642595			X																		
-177	RTD/Resistance Input Connector PCA	642603			X																		
-179	Digital Status Input Connector PCA	642629				X																	
-201 A1	Computer Interface PCA, Scan/Alarm	822932								X													
-201 A2	Alarm Annunciator PCA, Scan/Alarm	822924					X																

Index

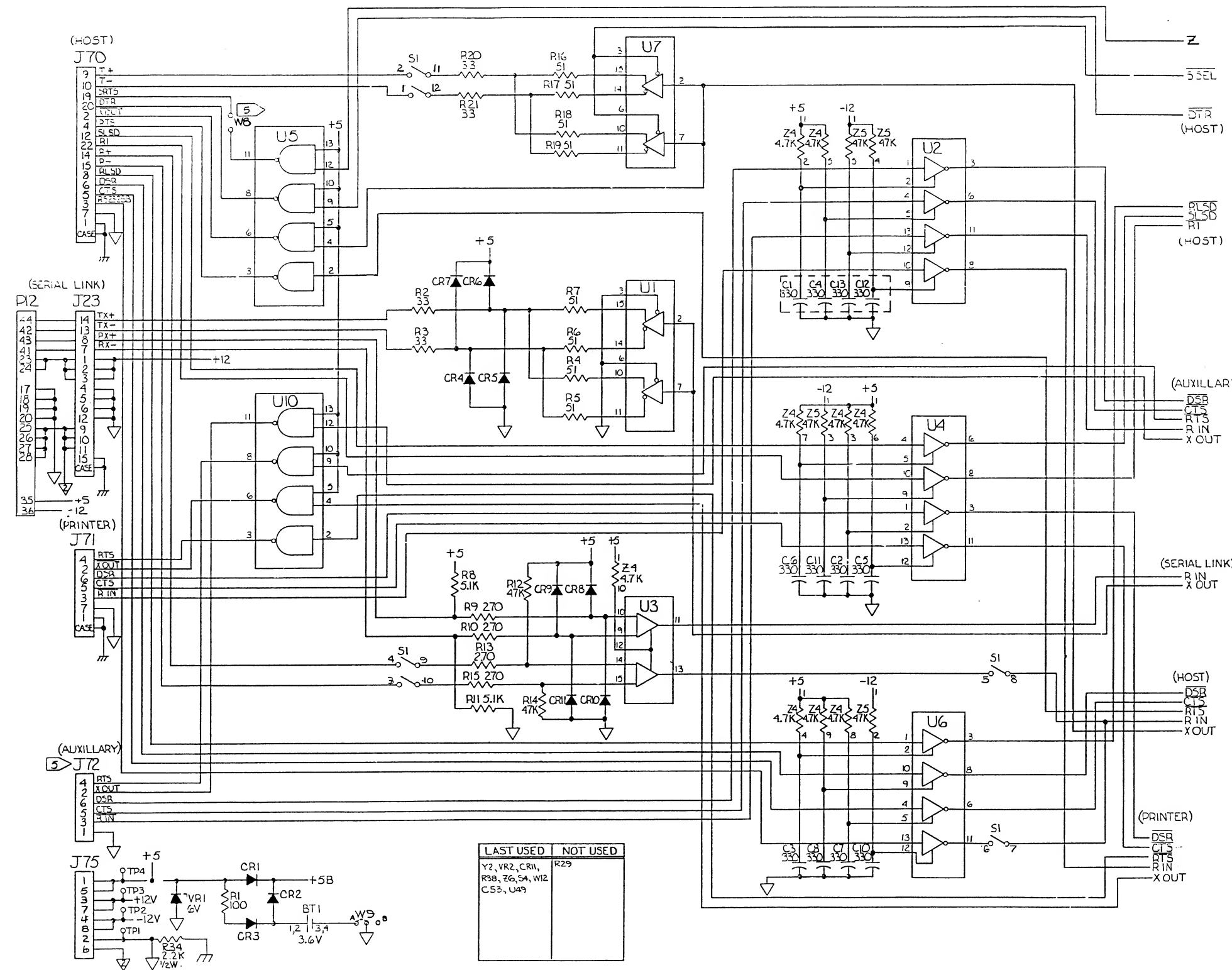**Index**

Index

Index

J2A J1A

J2B J1B

J2C J1C

J2D J1D

J2E

J1E

J2F J1F

VR1

R1

J12
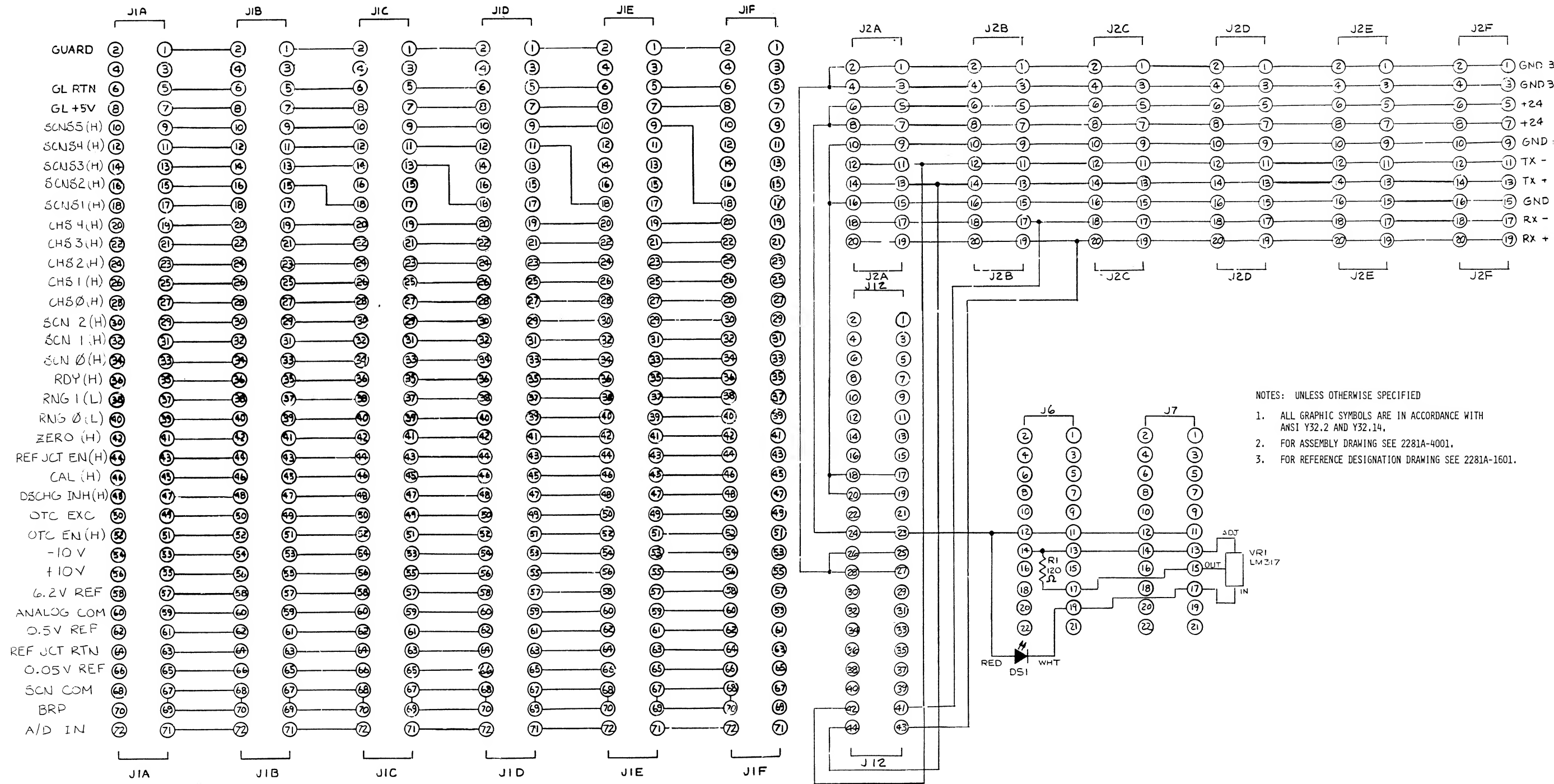
2281A-1601

Figure 7-1. A1 Motherboard PCA

2281A-1001

COMPUTER INTERFACE ASSY □ 793562 □ 865311 REV

SC

P12-44

P12-2
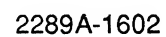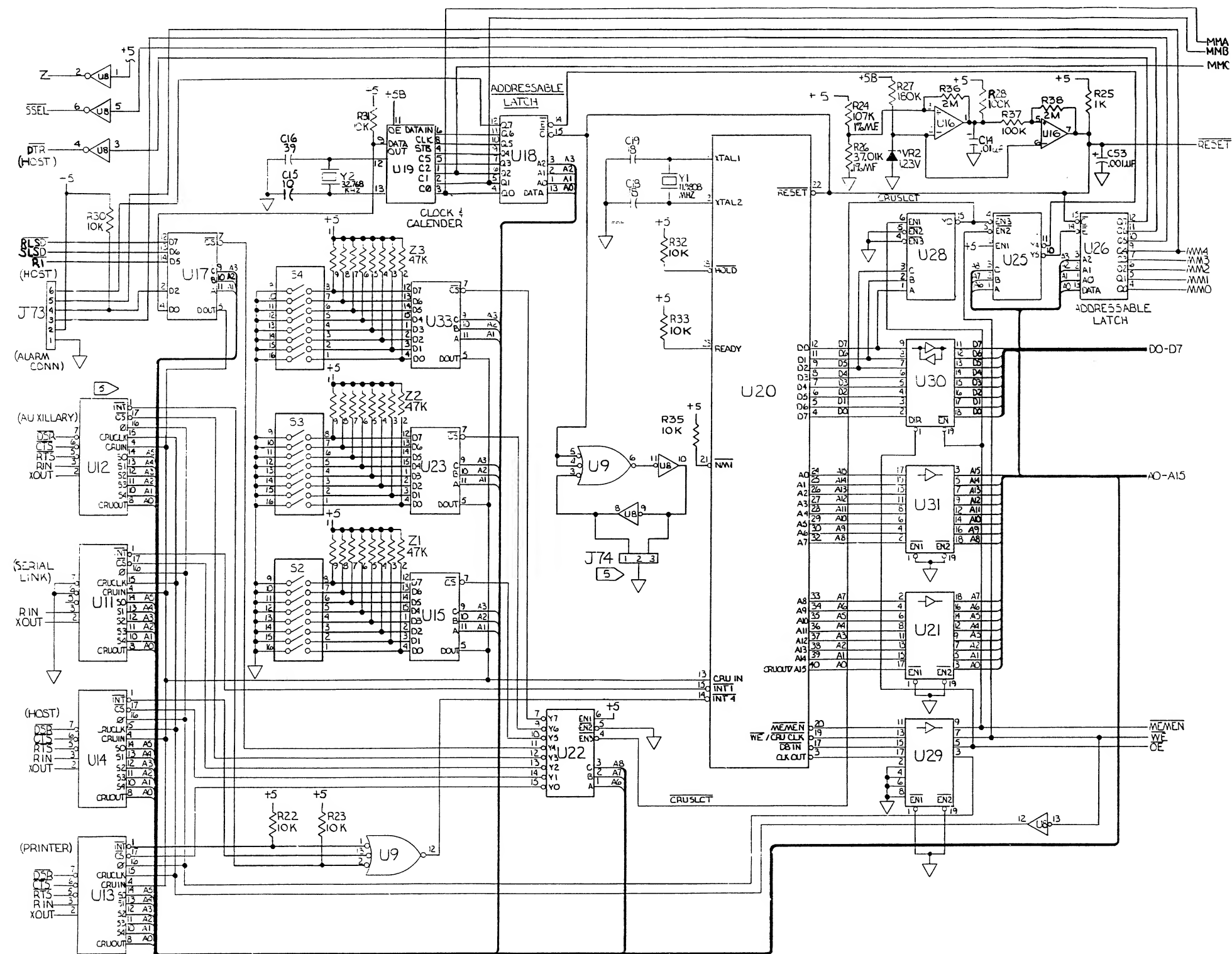
2289A-1602

NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL CAPACITORS ARE IN PF.
2. ALL RESISTORS ARE IN OHMS.
3. ALL RESISTORS ARE 1/4 W, 5%.
4. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.
5. THESE PARTS ARE NOT INCLUDED ON THE BASIC ASSY; CONSULT FACTORY.
6. W1-W6 ARE HARDWIRED ON THE PWB. AND EXIST FOR FUTURE USE.
7. CR4-CR11 DIODE 1N4933
8. CR1-CR3 DIODE S23738
9. Z3, SW4, J71, J73, U2, U10, U13, U33, C1, C4, C12, AND C13 ARE USED ON THE 2287A-4005 ONLY.
10. J74 IS USED ON THE 2289A-4002 ONLY.

LAST USED	NOT USED
Y2, VR2, CR11, R38, Z6, S4, W12 C53, U49	R29
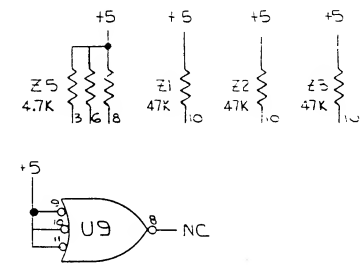
2289A-1002
(1 of 3)

Figure 7-2. A2 Computer Interface PCA

COMPUTER INTERFACE ASSY ☐ 793562 ☐ 865311 REV

SC

2289A-1602

	DEVICE#	+5	+5B	+12	-12	▽
U1	DS 1692	1				4,5,8
U2	MC 1489	14				7
U3	MC 3486	16				8
U4	MC 1489	14				7
U5	MC 1488			14	1	7
U6	MC 1489	14				7
U7	DS 1692	1				4,5,8
U8	LS 04	14				7
U9	LS 11	14				7
U10	MC 1488			14	1	7
U11	TMS 9902	18				9
U12	TMS 9902	18				9
U13	TMS 9902	18				9
U14	TMS 9902	18				9
U15	LS 251	16				8
U16	TLC 372		8			4
U17	LS 251	16				8
U18	LS 259	16				8
U19	μ PD1990		14			7
U20	TMS 9995	10				31
U21	LS 244	20				10
U22	LS 138	16				8
U23	LS 251	16				8
U24	HC 138		16			8
U25	LS 138	16				8
U26	LS 259	16				8
U27	HC 138		16			8
U28	LS 138	16				8
U29	LS 244	20				10
U30	LS 245	20				10
U31	LS 244	20				10
U32	LS 138	16				8
U33	LS 251	16				8
U34	μ PD4464		28			14
U35	μ PD4464		28			14
U36	μ PD4464		28			14
U37	μ PD4464		28			14
U38	μ PD4464		28			14
U39	μ PD4464		28			14
U40	μ PD4464		28			14
U41	μ PD4464		28			14
U42	μ PD4464		28			14
U43	μ PD4464		28			14
U44	2764-2					14
U45	2764-2					14
U46	2764-2					14
U47	μ PD4464					14
U48	2764-2					14
U49	2764-2					14

2289A-1002
(2 of 3)
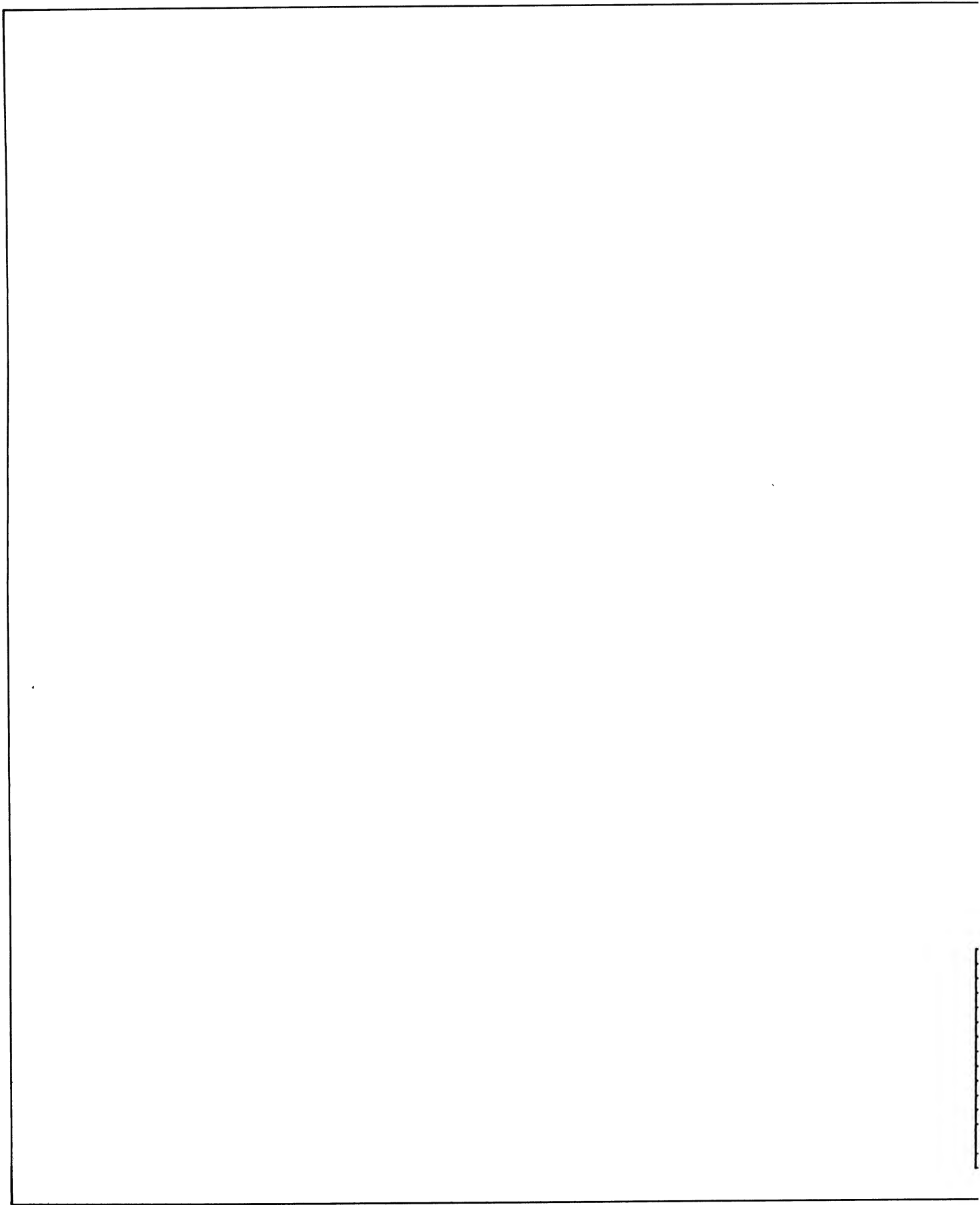
Figure 7-2. A2 Computer Interface PCA (cont)
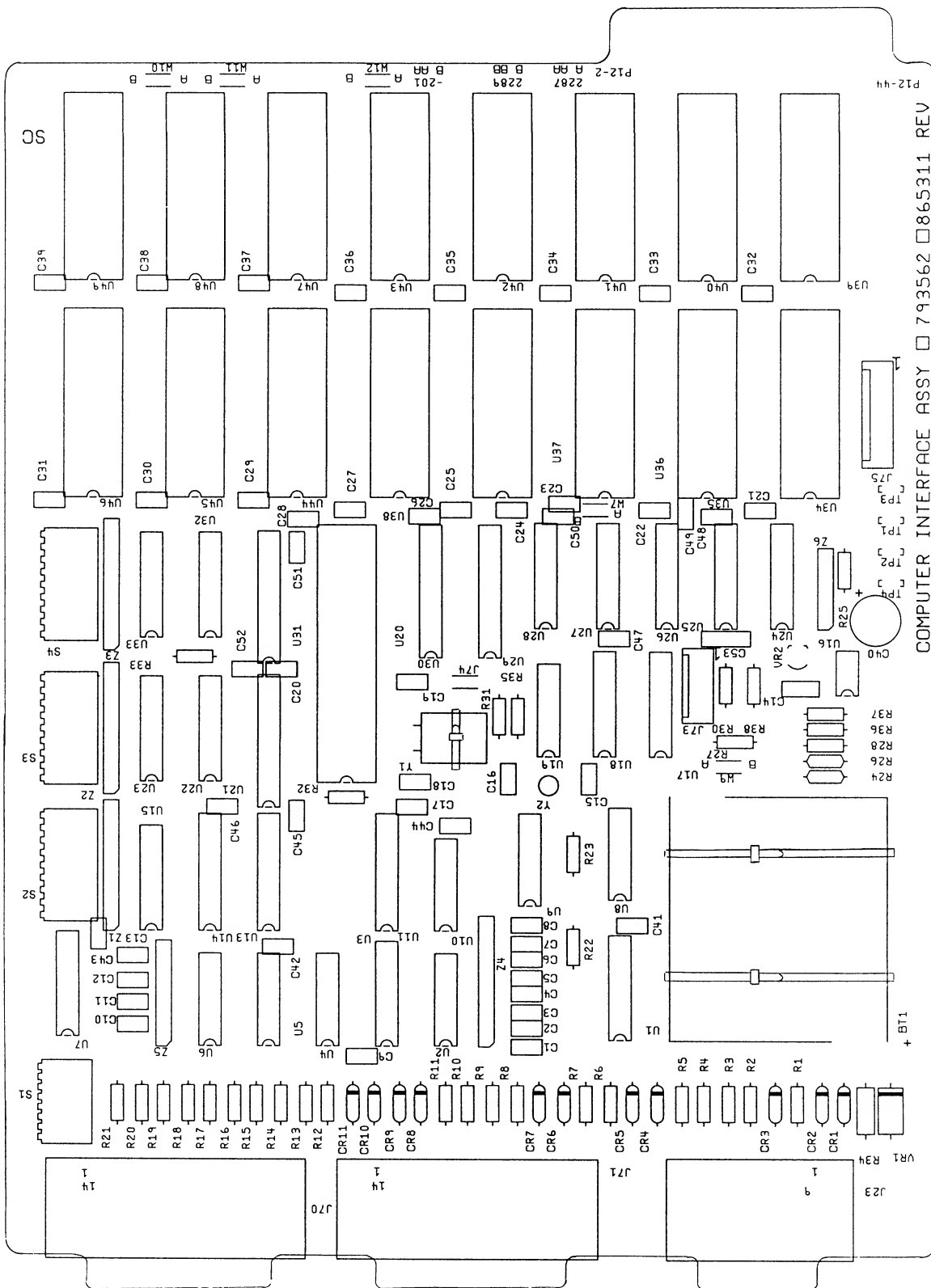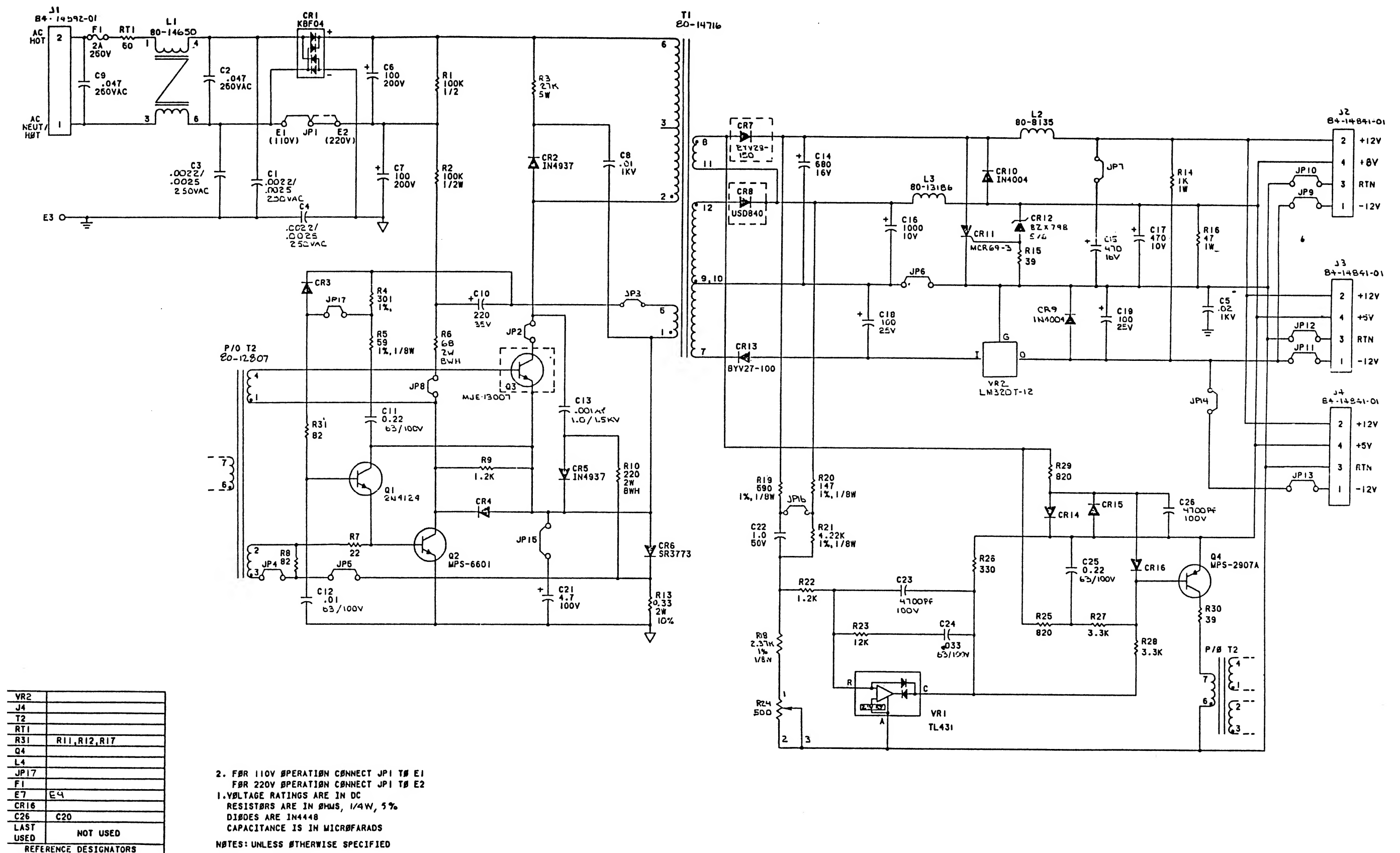
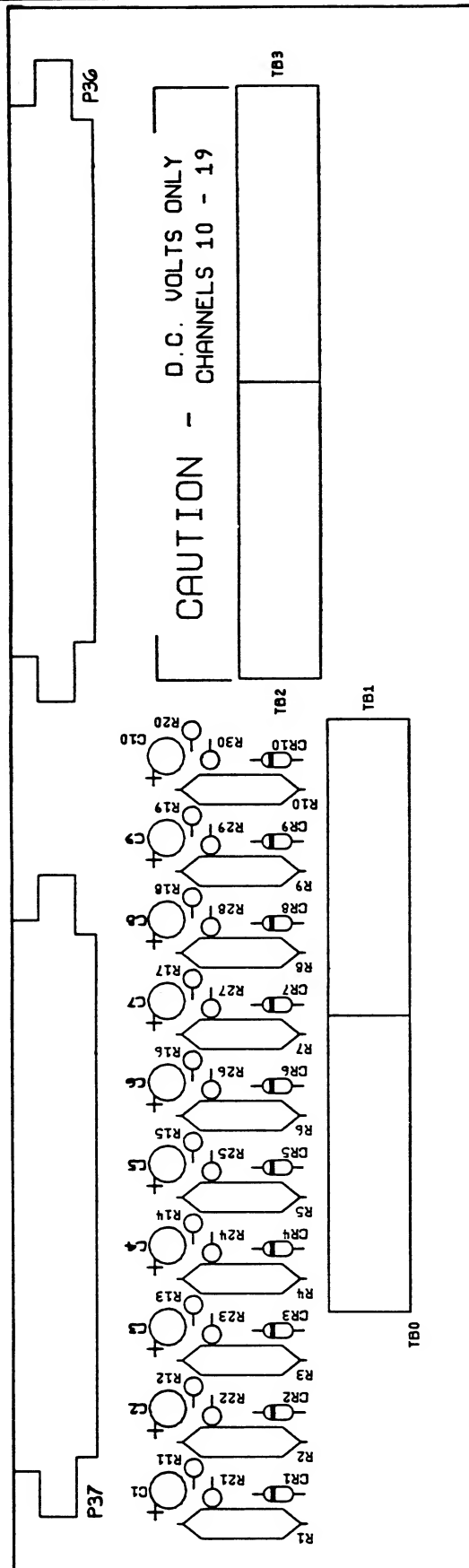COMPUTER INTERFACE ASSY ☐ 793562 ☐ 865311 REV

2289A-1602
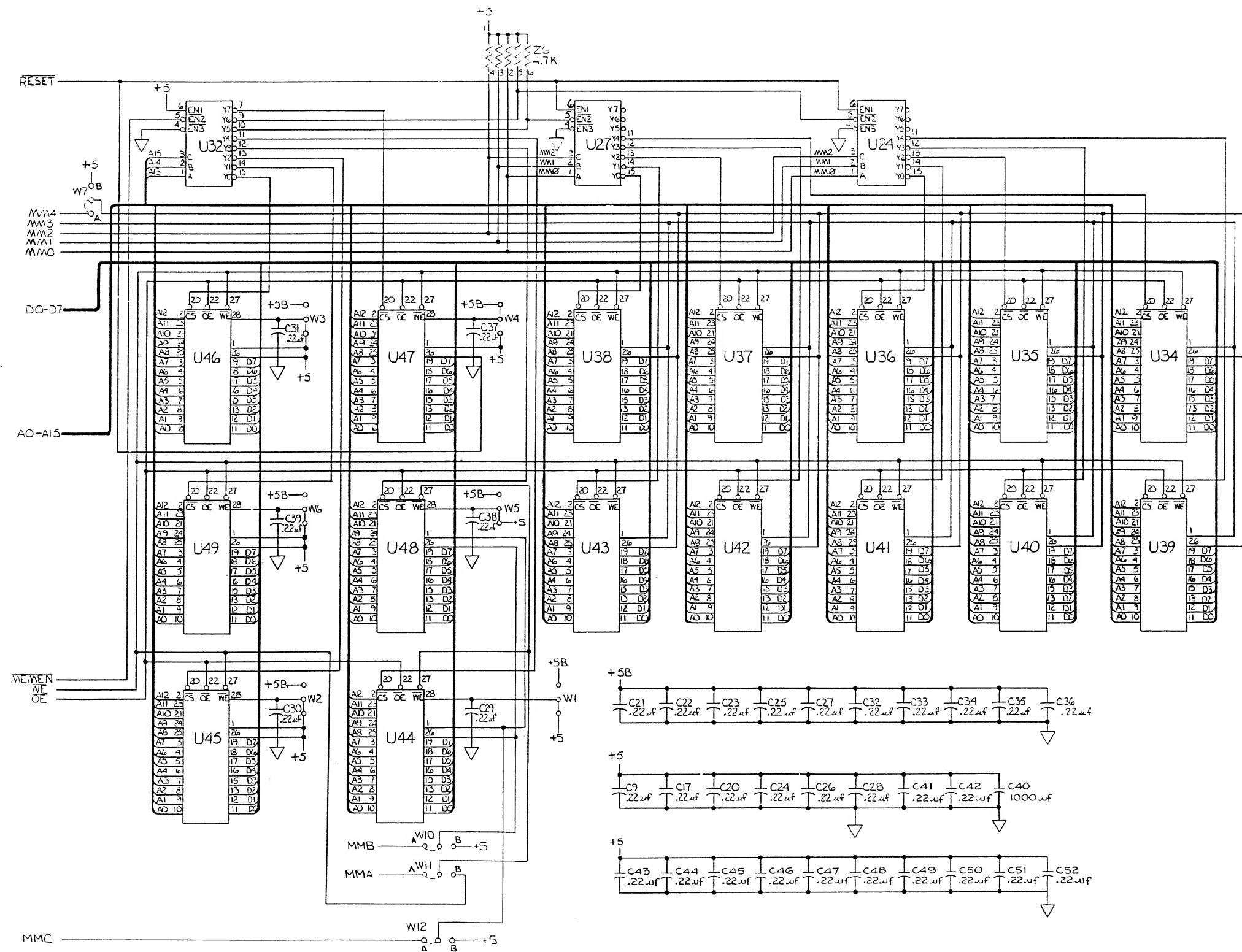
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(3 of 3)

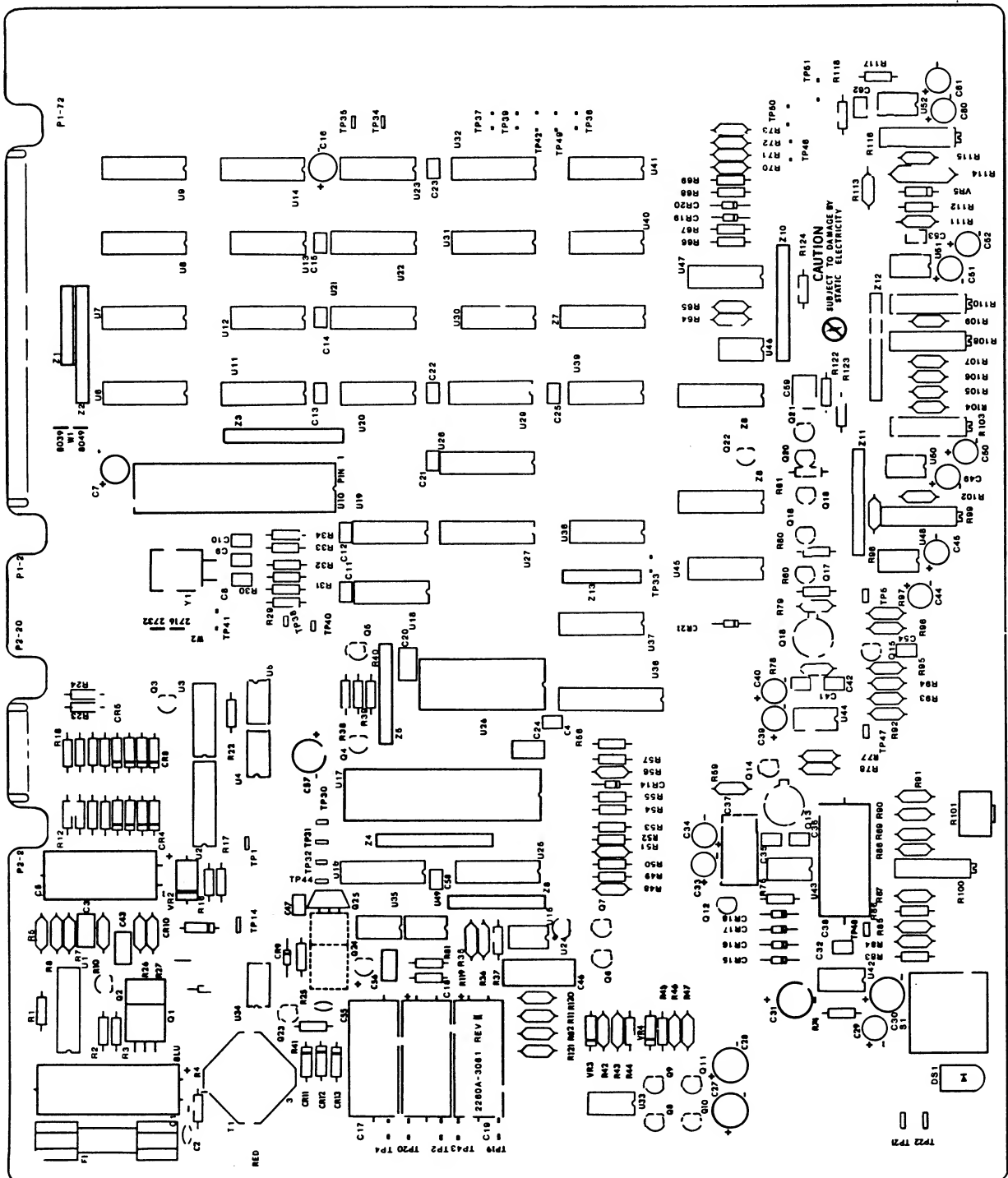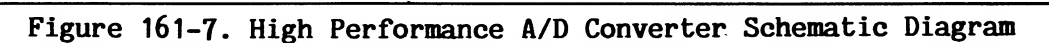Figure 7-2. A2 Computer Interface PCA (cont)

Figure 7-3. A3 Power Supply PCA

CAUTION - D.C. VOLTS ONLY
CHANNELS 10 - 19

P36

P37

TB3

TB2

TB1

TB0

R20 R30 CR10 C10 R10
R19 R29 CR9 C9 R9
R18 R28 CR8 C8 R8
R17 R27 CR7 C7 R7
R16 R26 CR6 C6 R6
R15 R25 CR5 C5 R5
R14 R24 CR4 C4 R4
R13 R23 CR3 C3 R3
R12 R22 CR2 C2 R2
R11 R21 CR1 C1 R1

NOTES: UNLESS OTHERWISE SPECIFIED.
1. FOR SCHEMATIC DIAGRAM SEE 2280A - 1060
2. FOR ASSEMBLY DRAWING SEE 2280A - 4060
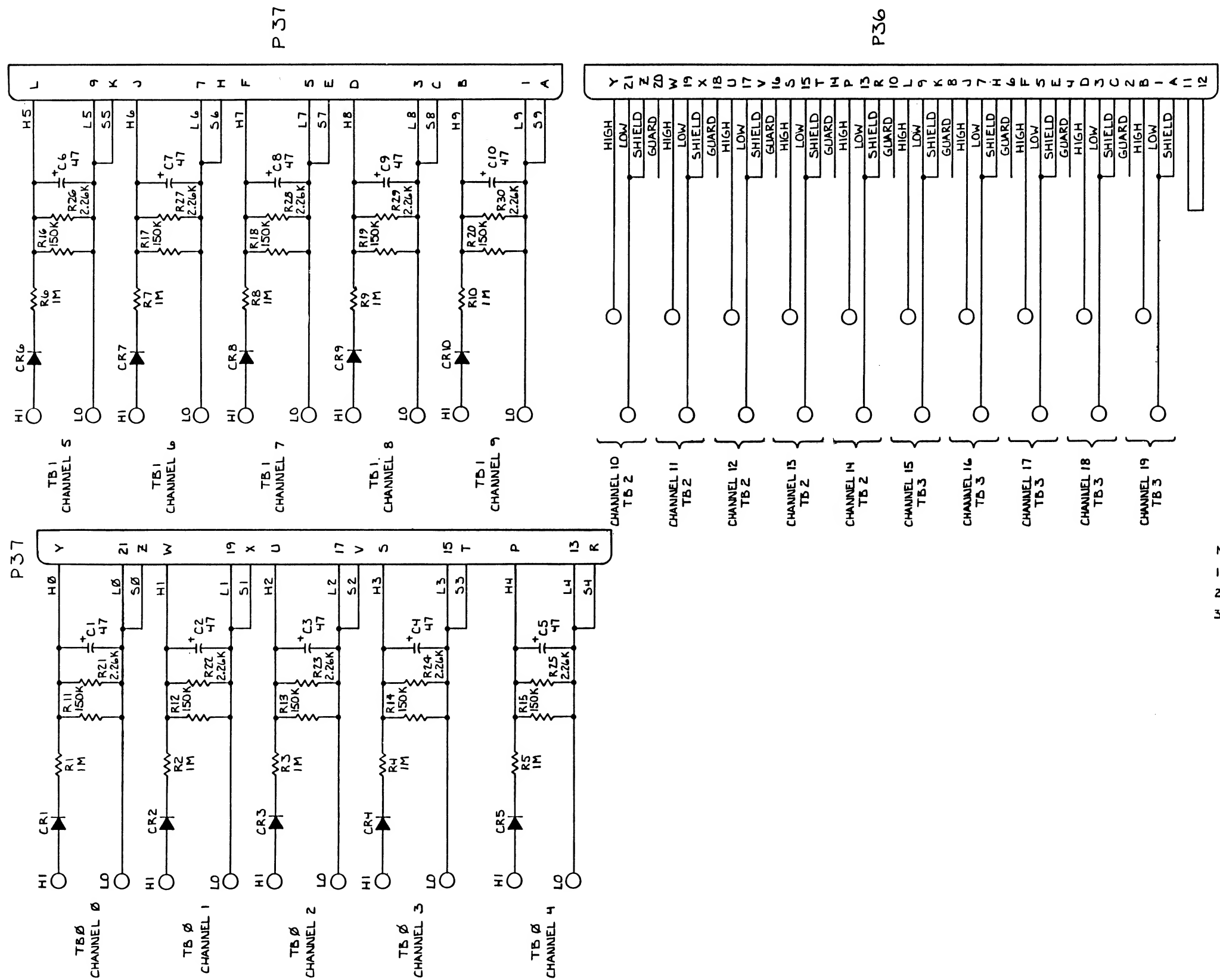
2280A-1660

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN MICROFARRADS.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

2280A-1060

Figure 160-2. AC Voltage Input Connector Schematic Diagram

160-F1

2280A-1661

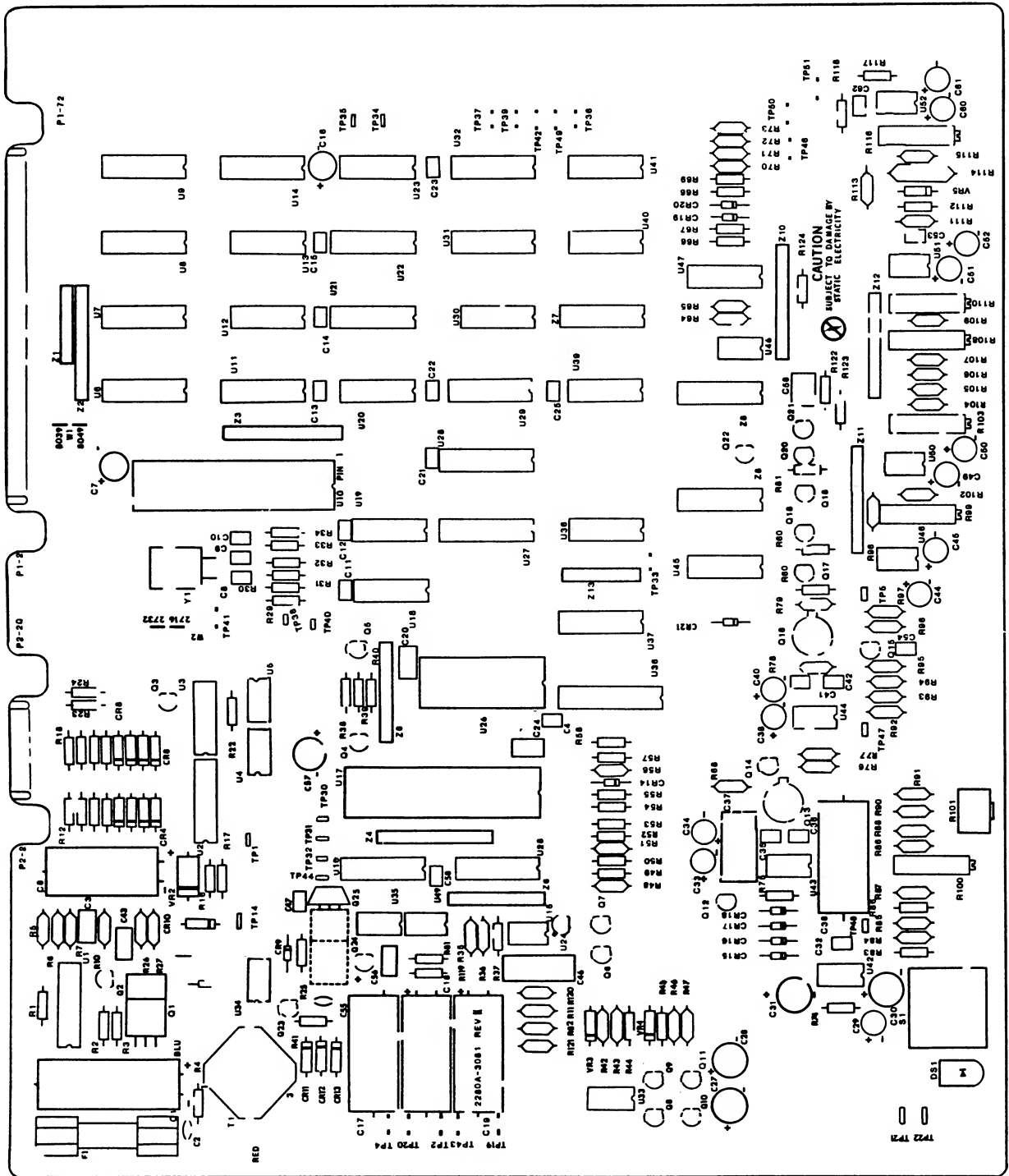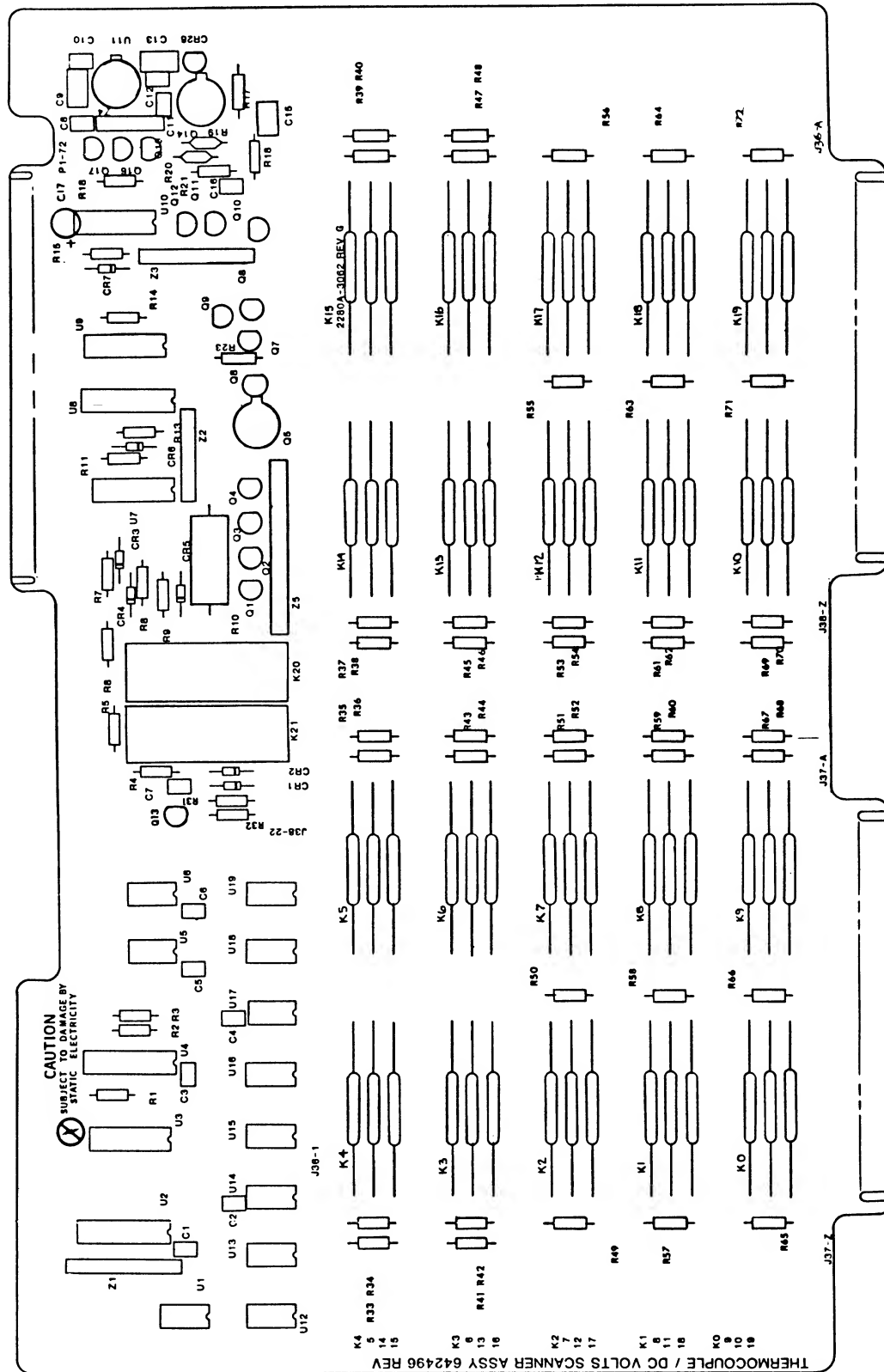Figure 161-7. High Performance A/D Converter Schematic Diagram

2280A-1661

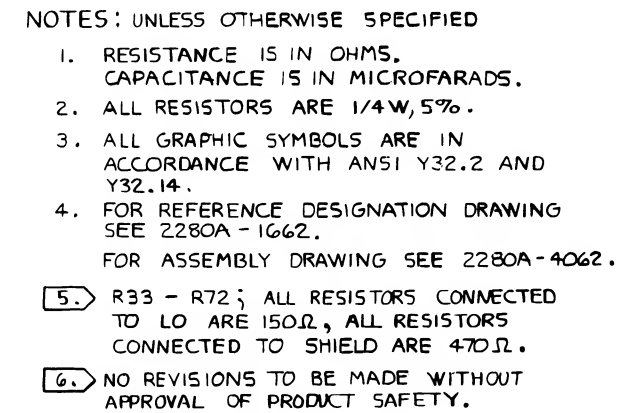Figure 161-7. High Performance A/D Converter Schematic Diagram (cont)

NOTES: UNLESS OTHERWISE SPECIFIED

[11] REFER TO SOLE SOURCE PLAN FOR JF/PN 586081, READ THE FOLLOWING NOTE [12]

[12] PROVISIONS HAVE BEEN MADE FOR INSTALLATION OF THE ABOVE COMPONENTS AS A BACKUP FOR THE INAVAILABILITY OF U2, DS1692.

2280A-1061
(2 of 3)

2280A-1661
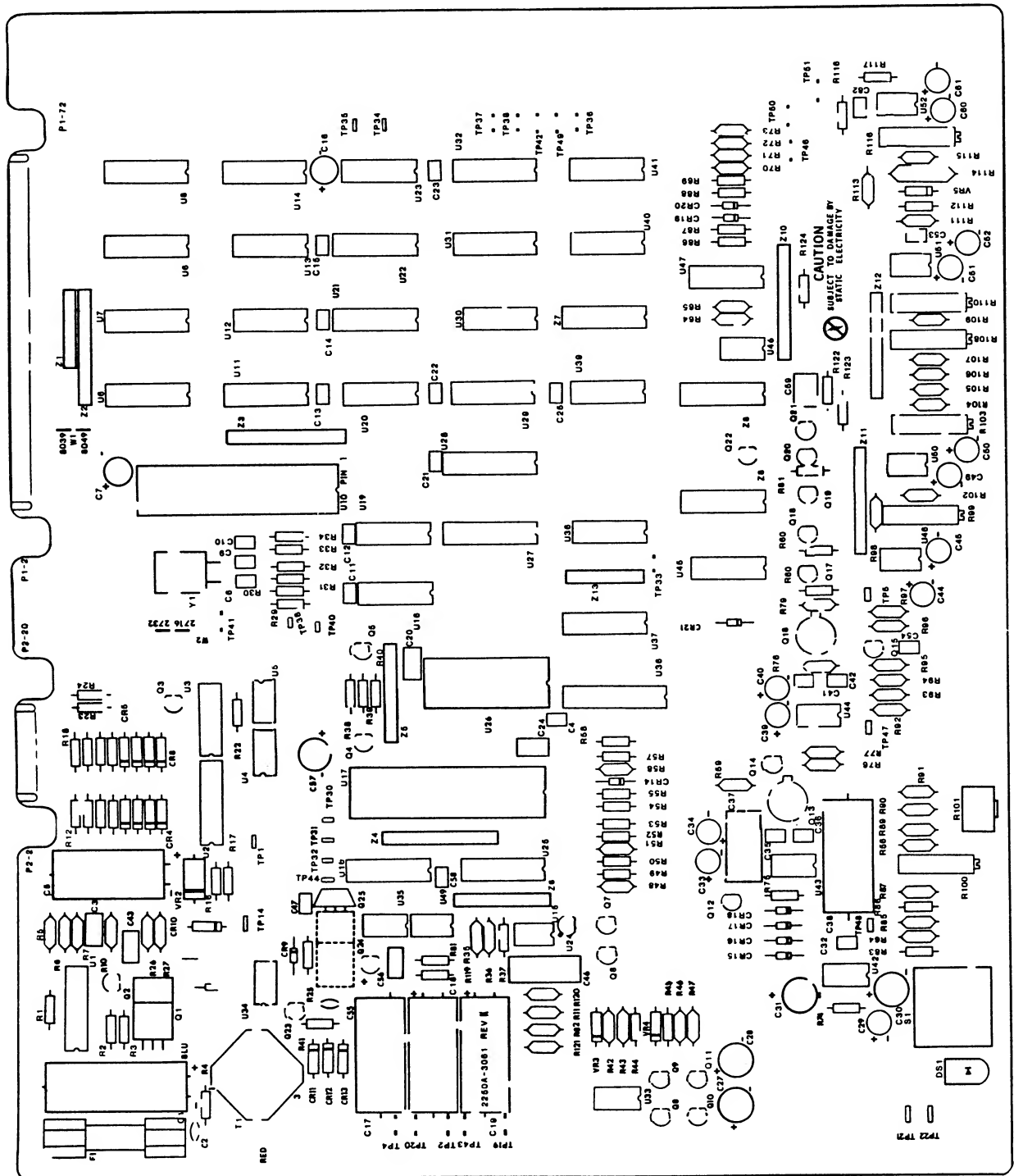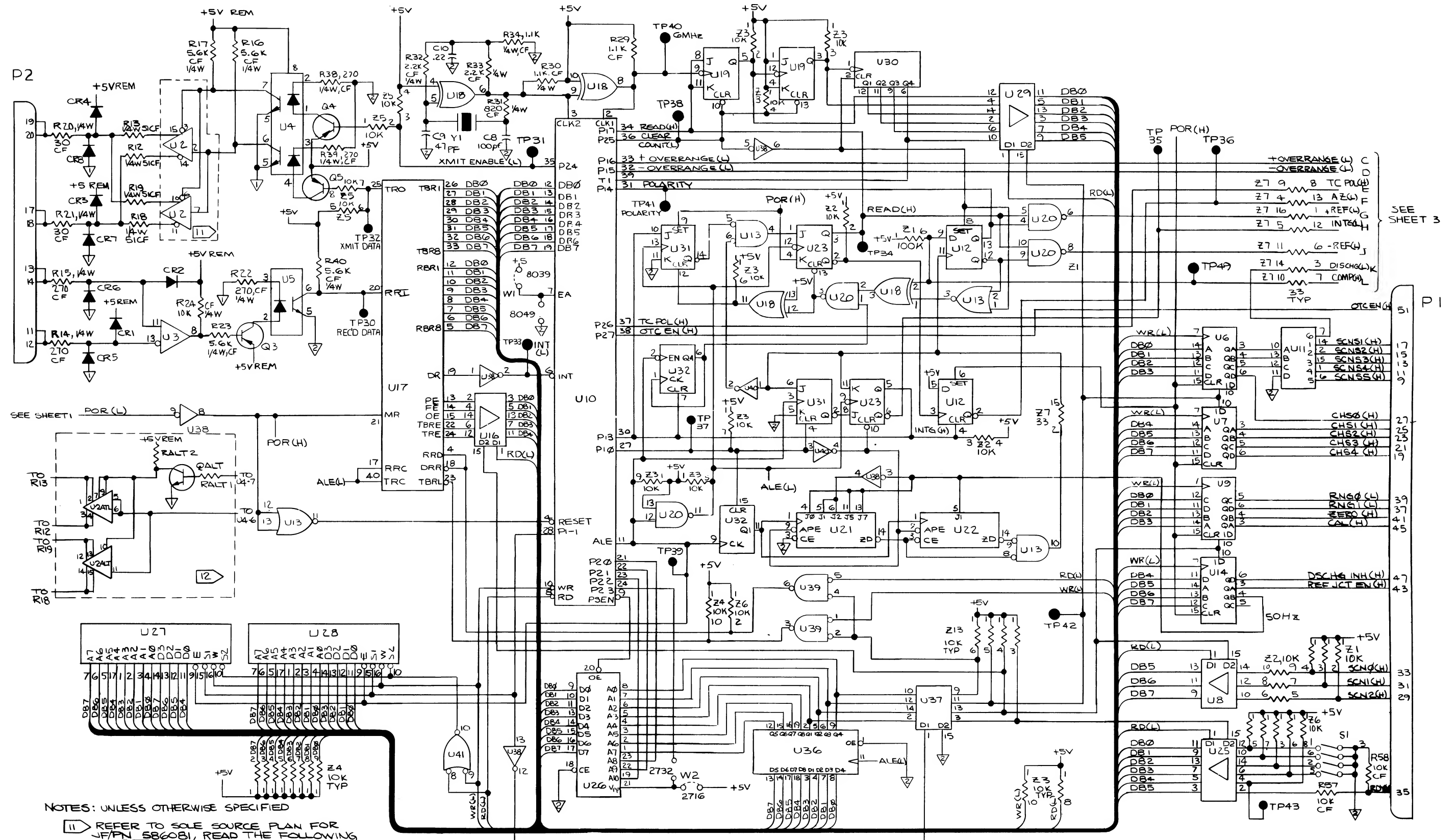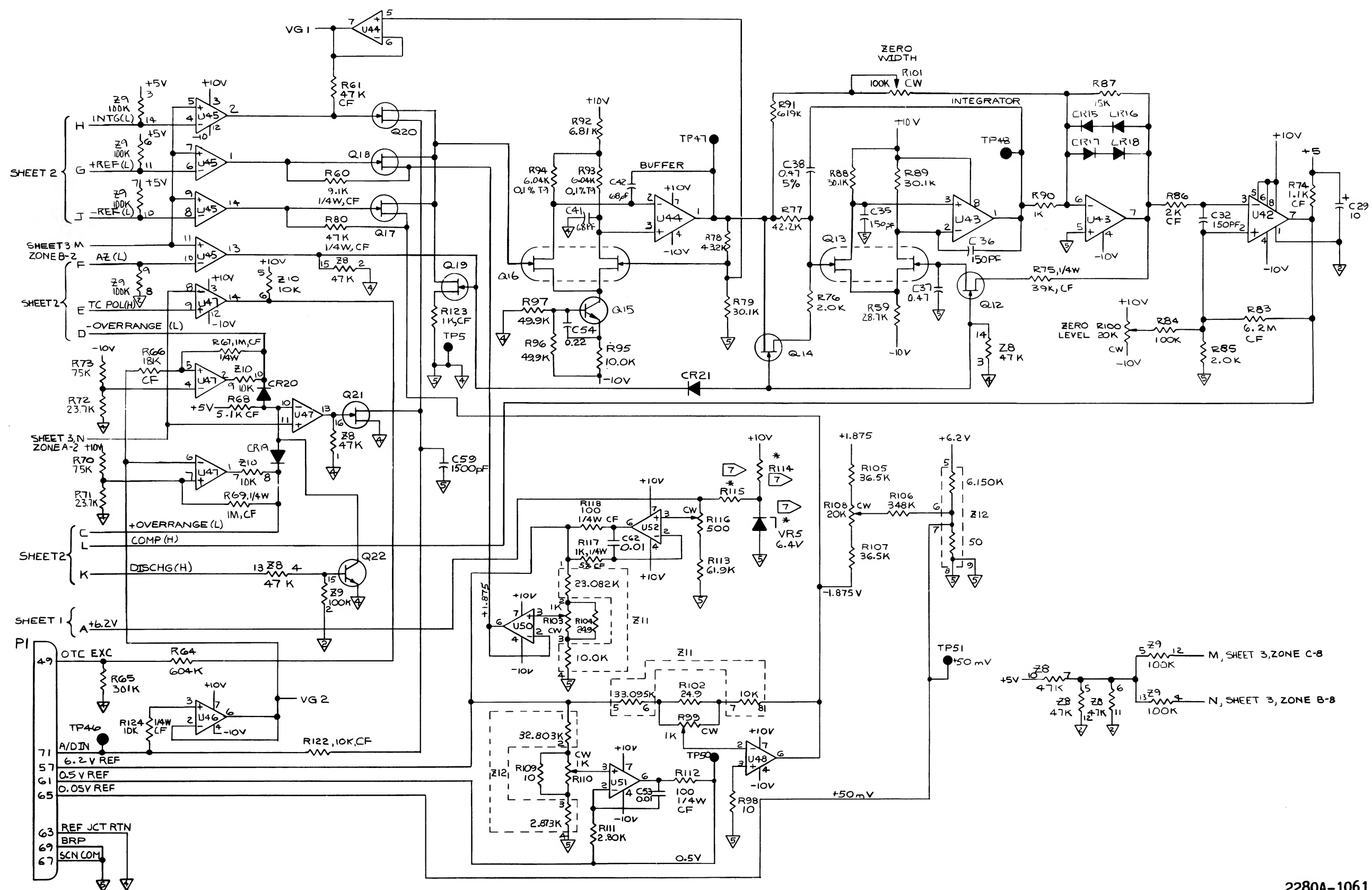
2280A-1061
(3 of 3)

Figure 161-7. High Performance A/D Converter Schematic Diagram (cont)

2280A-1662
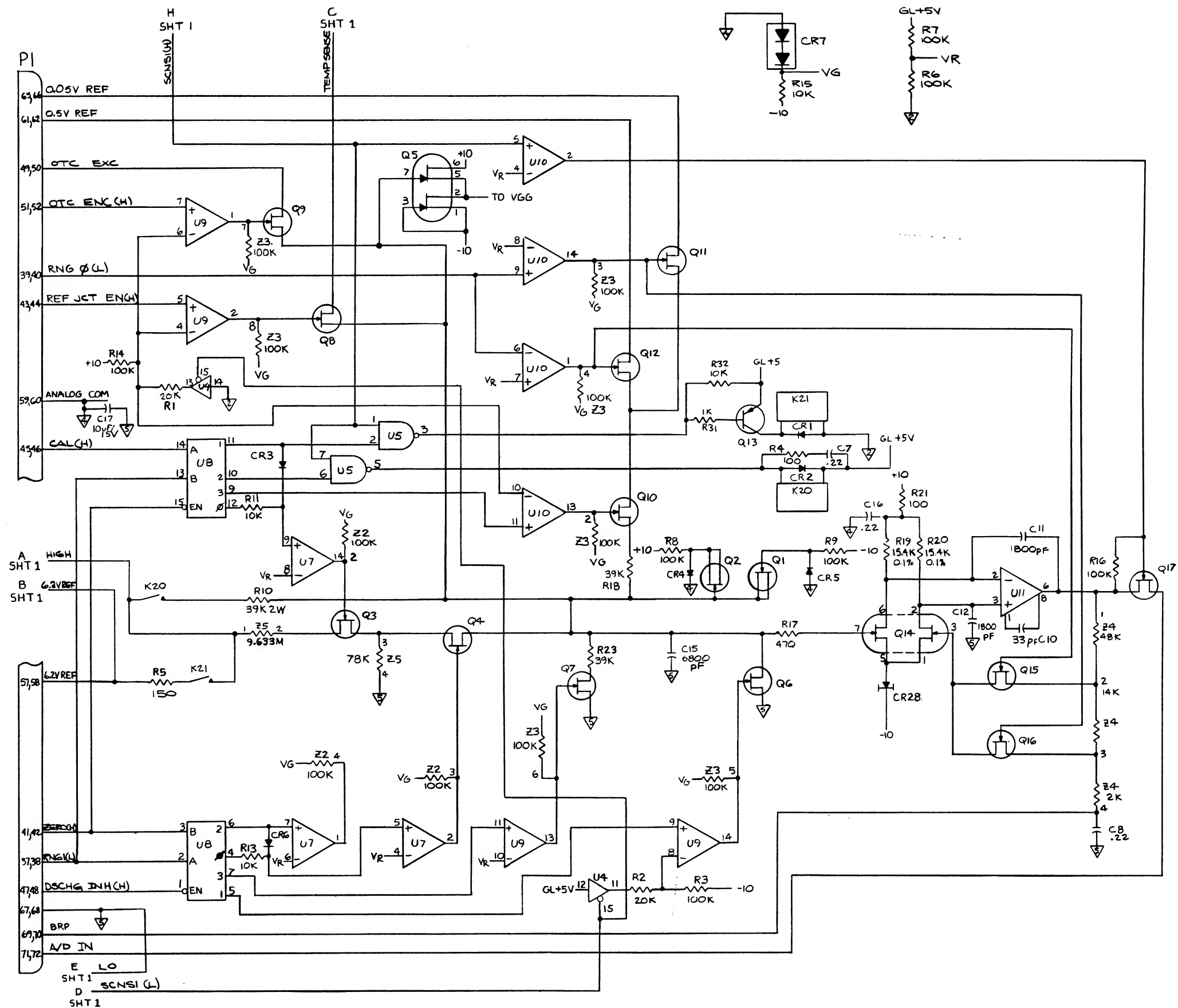
Figure 162-2. Thermocouple/DC Volts Scanner Schematic Diagram

2280A-1062
(1 of 2)

THERMOCOUPLE / DC VOLTS SCANNER ASSY 642496 REV

2280A-1662

Figure 162-2. Thermocouple/DC Volts Scanner Schematic Diagram (cont)

2280A-1062
(2 of 2)

2280B-1663

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTANCES ARE IN OHMS.
   ALL CAPACITANCES ARE IN MICROFARADS.
2. ALL RESISTORS ARE 1/4 W, 5%.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 & Y32.14.
4. CR8-27, KØ-19, P38 ARE SHOWN ON SHEET 2 FOR REFERENCE ONLY.

LAST USED
R45, C17, Q27, VR5, U23, CR27, Z4, K22, L1, W4

NOT USED
CR5-7, R27-29

I.C. POWER AND GROUND					
REF. DES.	GL+5V	▽	+10	-10	VG	DEVICE NAME
U1	14	7				4011B
U2	14	7				4071B
U3	16	8				CD4028B
U4		5,15				CA3081
U5	8	4				40107
U6	16	8				CD4028B
U7		5,15				CA3081
U8	8	4				40107
U9	14	7				4011B
U10		5,15				CA3081
U11			7	4		OP-07
U12			7	4		OP-07
U13			3	12		LM239
U14	16	8				80C97
U15			3	12		LM239
U16			7	4		LM208
U17	14	7				4011B
U18	14	7				4001B
U19			3	12		LM239
U20			7	4		OP-07
U21			7	4		TLØ81IJG
U22			7	4		LM208
U23			7	4		OP-Ø7
Z1	1					—
Z2					1	—
Z3					1	—

2280B-1063
(Sheet 1 of 3)
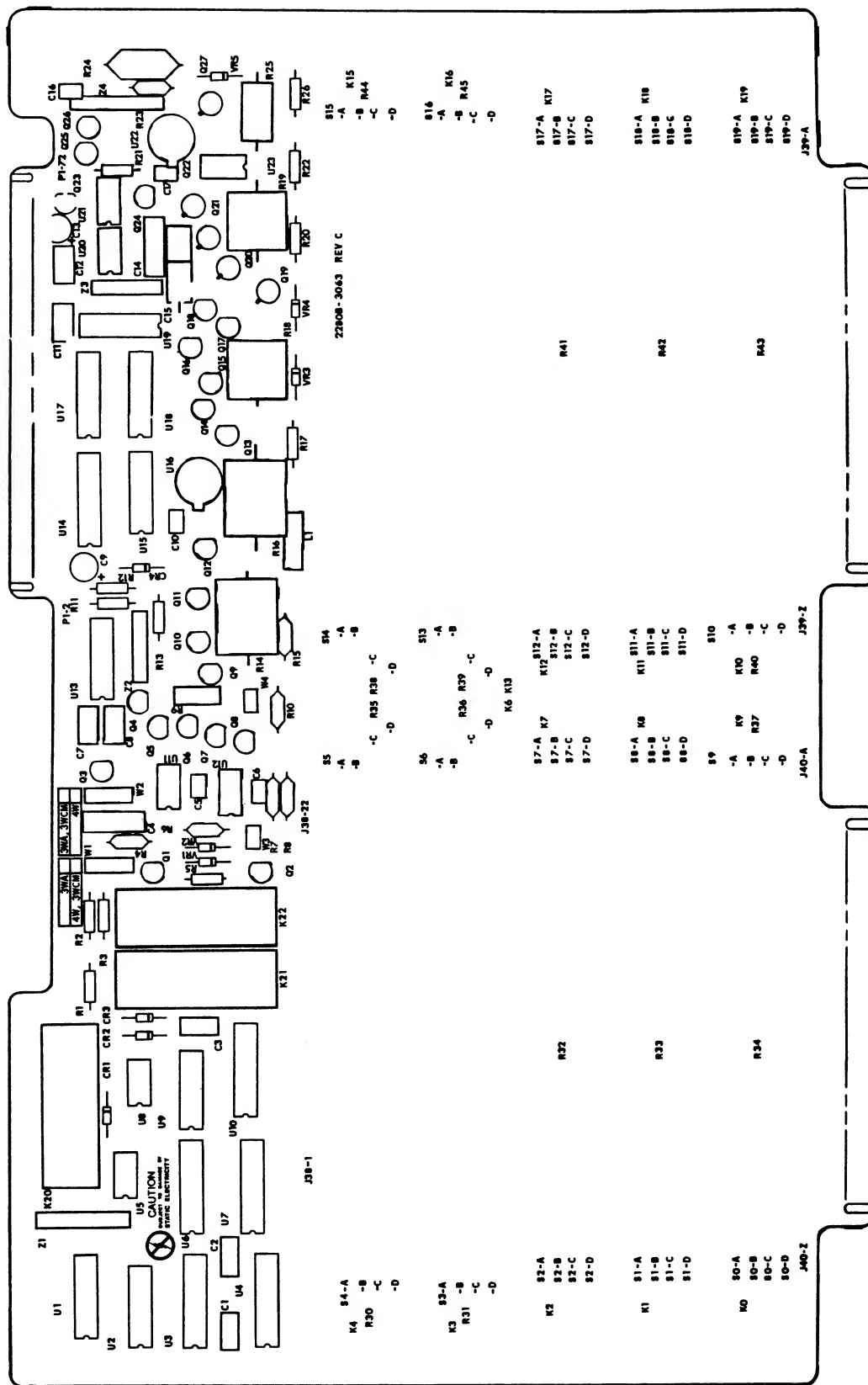
Figure 163-14. RTD-Resistance Scanner Schematic

2280B-1663
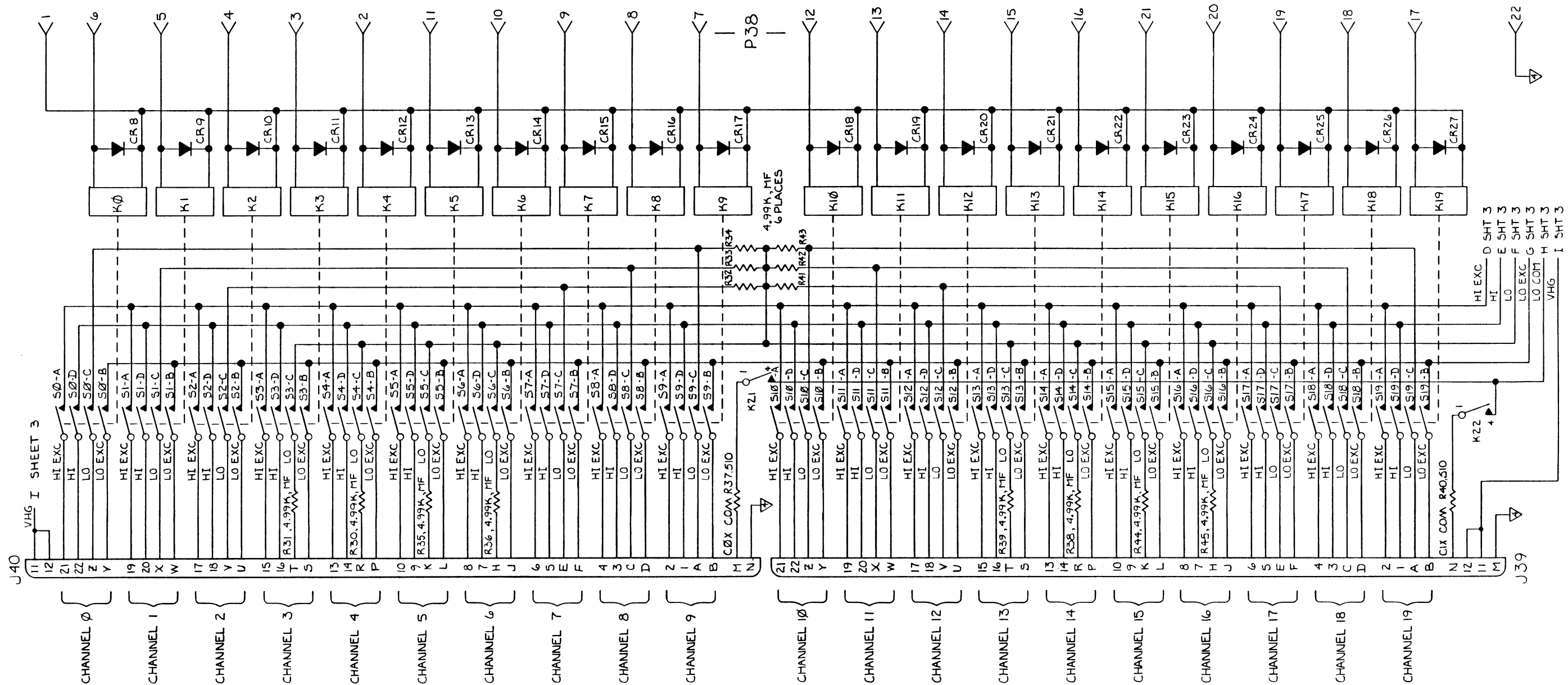
2280B-1063
(Sheet 2 of 3)
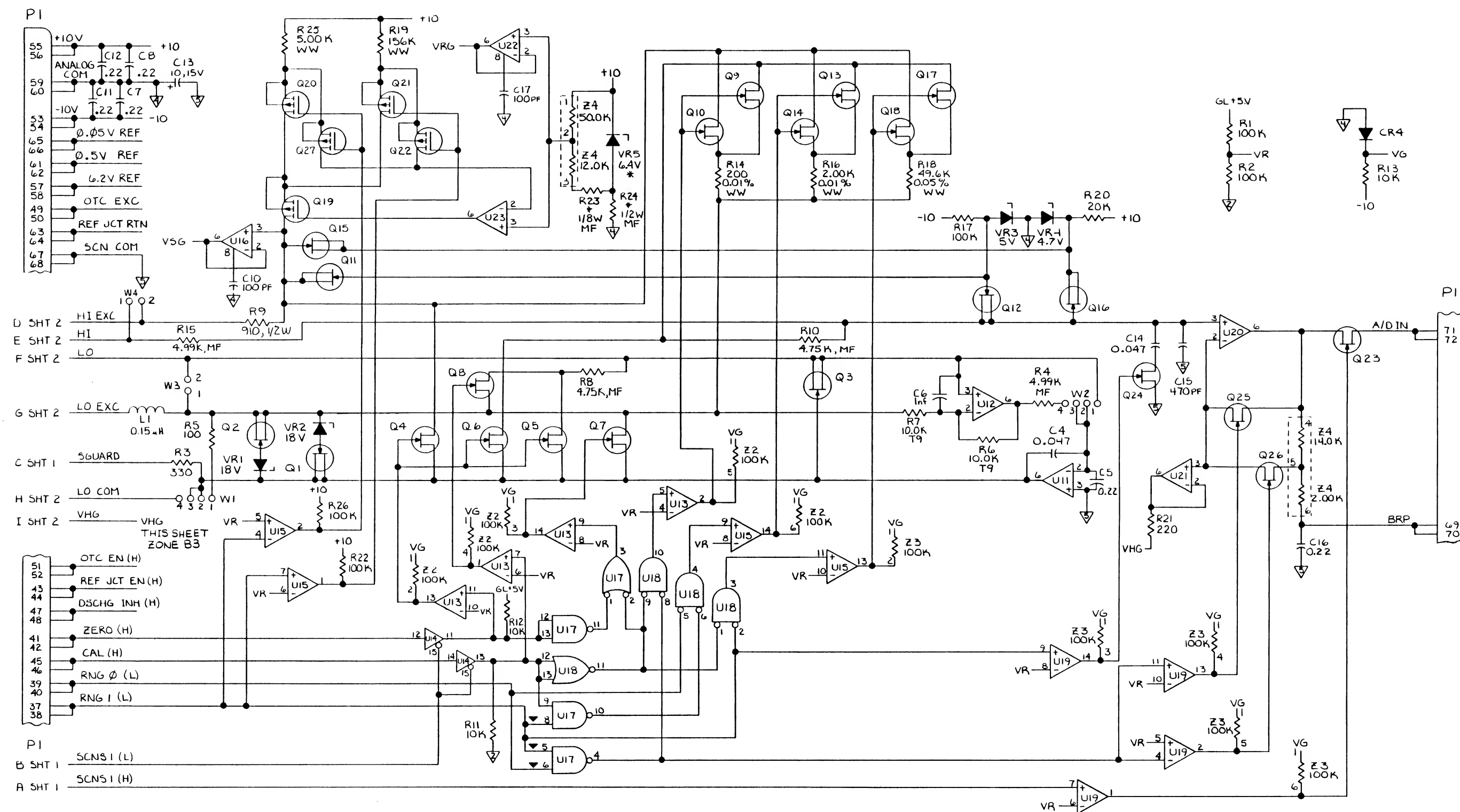
Figure 163-14. RTD-Resistance Scanner Schematic (cont.)

2280B-1663
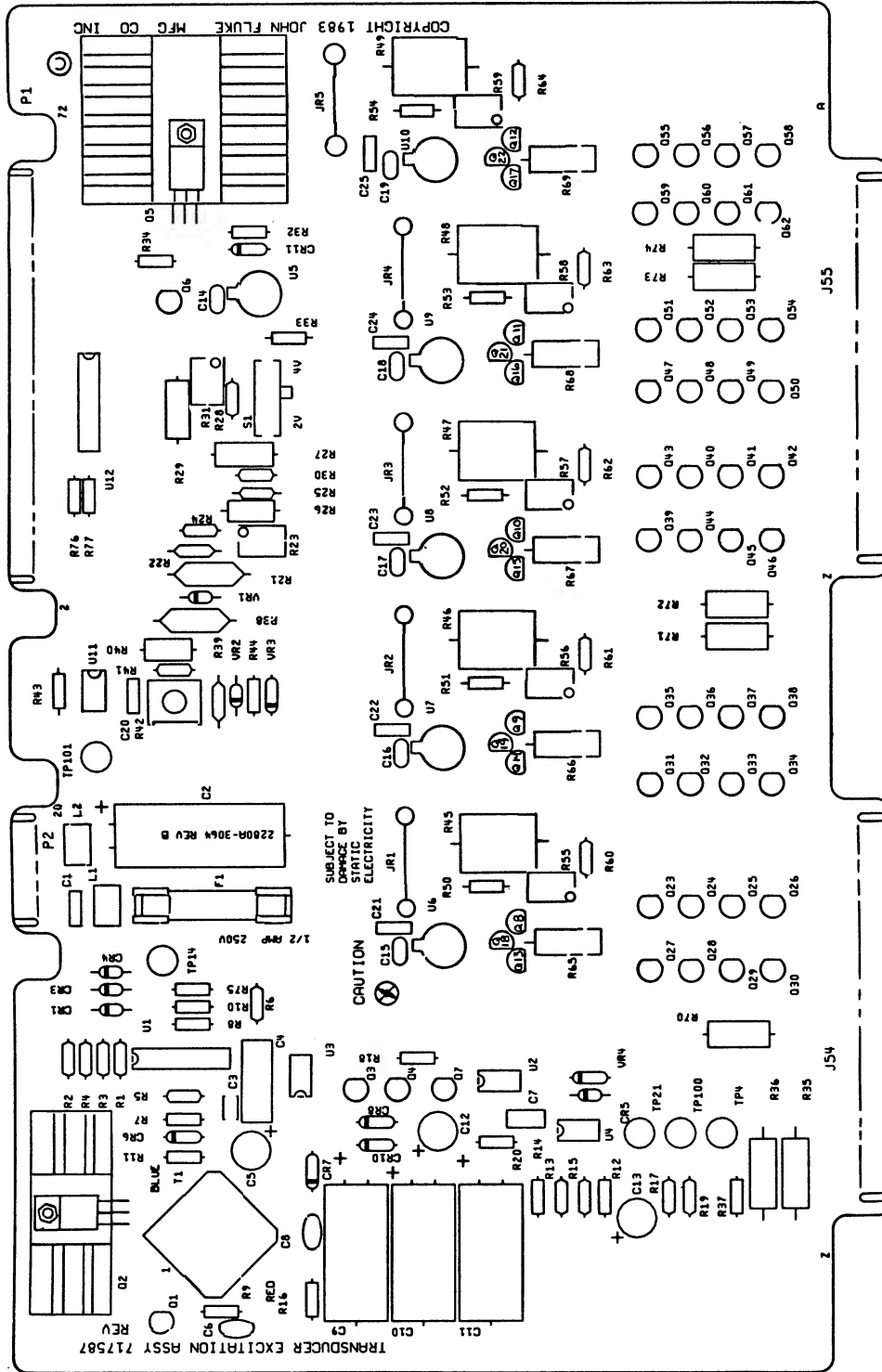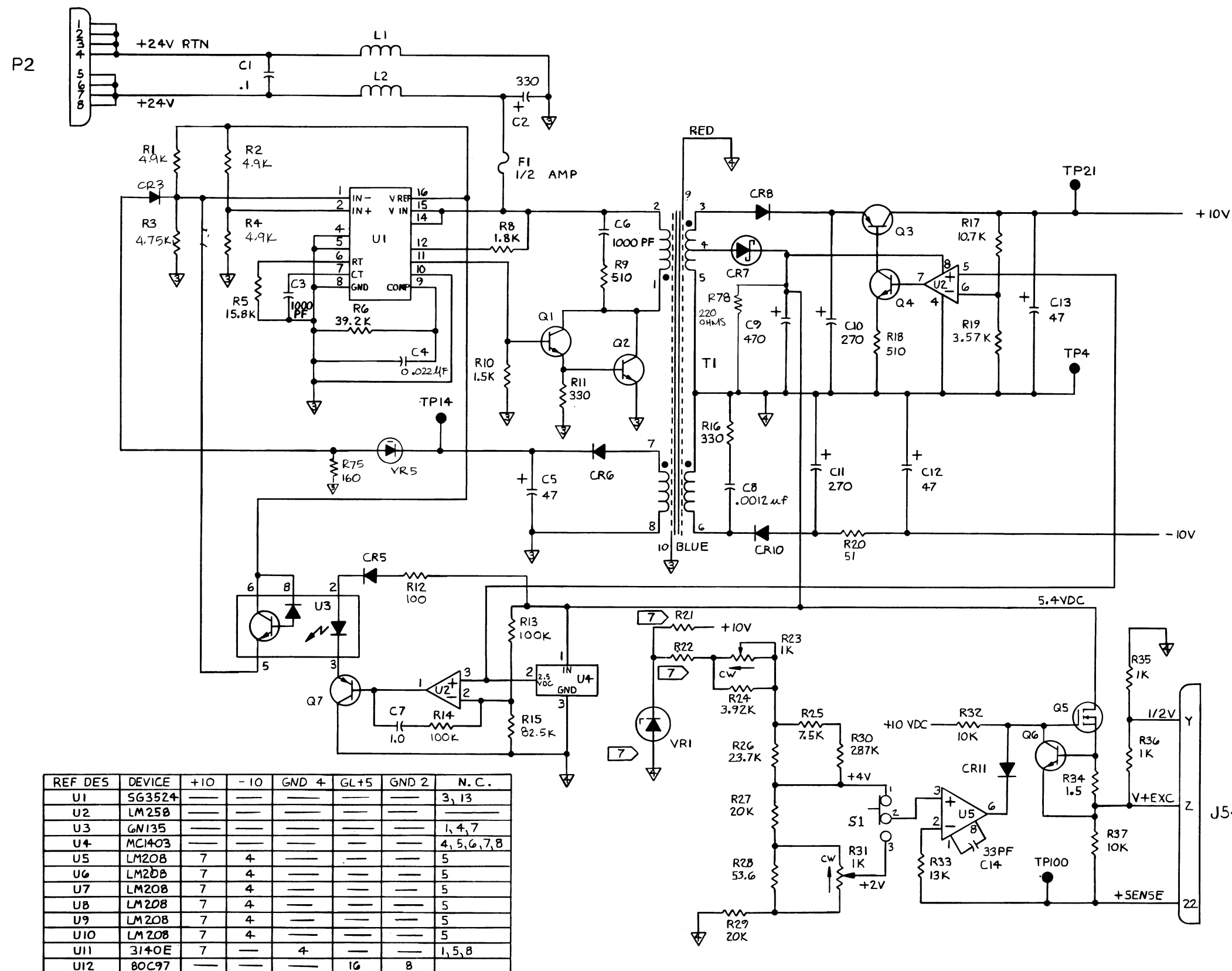
2280B-1063
(Sheet 3 of 3)

Figure 163-14. RTD-Resistance Scanner Schematic (cont.)
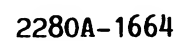
2280A-1664

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IS IN OHMS.

2. ALL CAPACITANCE IS IN MICROFARADS.

3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

4. FOR REFERENCE DESIGNATION DRAWING SEE 2280A-1664.

5. FOR ASSEMBLY DRAWING SEE 2280A-4064.

6. R38, R39, AND VR2 IS A MATCHED REFERENCE SET.

7. R21, R22, AND VR1 IS A MATCHED REFERENCE SET.

REF DES		
LAST USED	NOT USED	
R78	Q62	CR2,9
U12	C25	
CR11	VR4	
T1	JR5	
L2		

REF DES	DEVICE	+10	-10	GND 4	GL+5	GND 2	N.C.
U1	SG3524	—	—	—	—	—	3,13
U2	LM258	—	—	—	—	—	
U3	GN135	—	—	—	—	—	1,4,7
U4	MC1403	—	—	—	—	—	4,5,6,7,8
U5	LM208	7	4	—	—	—	5
U6	LM208	7	4	—	—	—	5
U7	LM208	7	4	—	—	—	5
U8	LM208	7	4	—	—	—	5
U9	LM208	7	4	—	—	—	5
U10	LM208	7	4	—	—	—	5
U11	3140E	7	—	4	—	—	1,5,8
U12	80C97	—	—	—	16	8	

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(1 of 3)

Figure 164-5. Transducer Excitation Module Schematic Diagram

TRANSDUCER EXCITATION ASSY 717587 REV

2280A-3064 REV B

1/2 AMP 250V

CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY
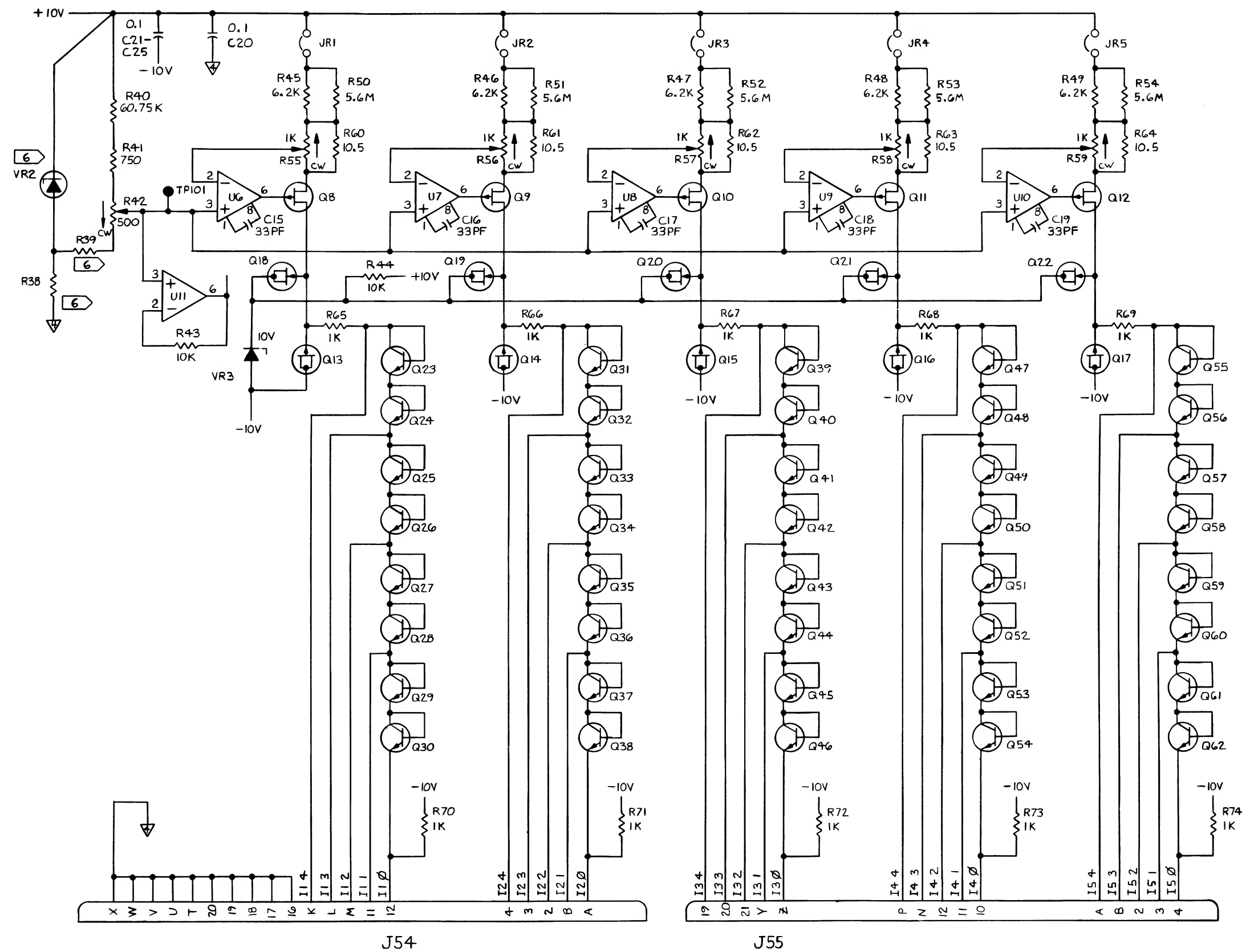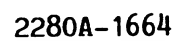
2280A-1664

Figure 164-5. Transducer Excitation Module Schematic Diagram (cont)

2280A-1064
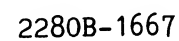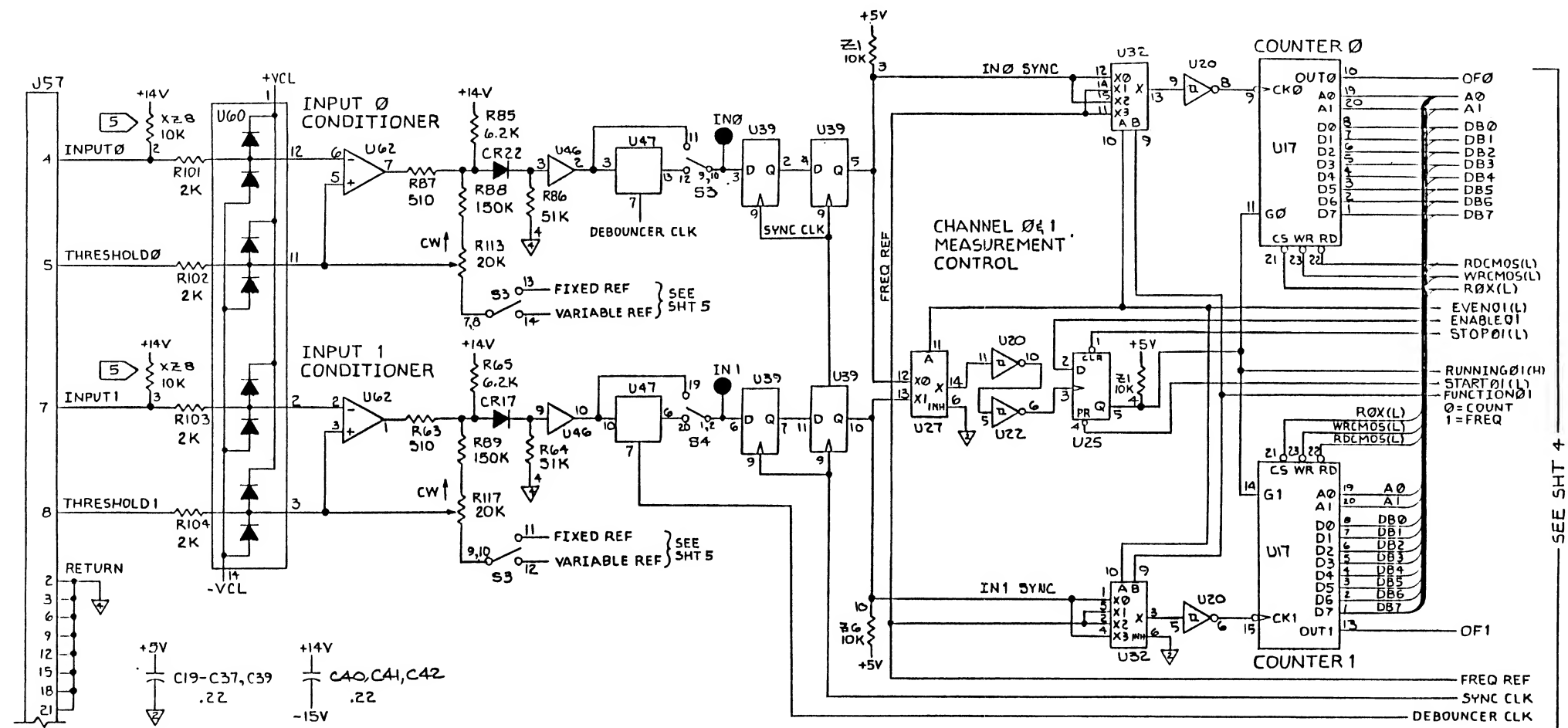(2 of 3)

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P1

T2

JR5

R49

R59

R64

R54

U10

Q12

Q17

R69

Q55 Q56 Q57 Q58

Q59 Q60 Q61 Q62

R74

R73

J55

Q5

CR11

R32

R34

R48

JR4

R53

R58

R63

U9

Q11

Q16

Q51 Q52 Q53 Q54

C25

C19

C14

Q10

U5

R33

C24

R68

Q47 Q48 Q49 Q50

Q39 Q40 Q41 Q42

R31 R28

S1

2V

4V

R27

R30

R25

R26

R47

JR3

R52

R57

R62

U8

Q15

Q20

R67

Q43 Q44 Q45 Q46

R29

U12

C17

C23

R76 R77

R24

R23

R22

R21

VR1

R38

R39 VR2 VR3

R46

JR2

R51

R56

R61

U7

Q14

Q19

R66

Q35 Q36 Q37 Q38

Q31 Q32 Q33 Q34

R71 R72

U11

R40

R41

R43

C20 R42

TP101

C22

C16

C2

2280A-3064 REV B

L2

P2

C1

L1

F1

1/2 AMP 250V

SUBJECT TO DAMAGE BY STATIC ELECTRICITY

CAUTION

R45

JR1

R50

R55

R60

U6

Q18

Q13

R65

C21

C15

Q23 Q24 Q25 Q26

Q27 Q28 Q29 Q30

TP14

R75

R8 R10

R6

U1

U3

R18

U2

VR4

C7

U4

CR5

TP21

TP100

TP4

R36 R35

R70

J54

R2 R4 R3 R1

R5 R7 R6

R11

BLUE

T1

C3

C4

C5

R40

R39

Q7

C12

R20

R13 R15 R12 R17

C13

R19

R37

CR6

CR10

CR7

C8

Q2

D1

RED

R16

R9

Q1

C6

REV

C9 C10 C11

TRANSDUCER EXCITATION ASSY 717587

2280A-1664

Figure 164-5. Transducer Excitation Module Schematic Diagram (cont)

2280B-1667

COUNTER Ø
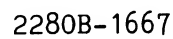
INPUT Ø CONDITIONER

INPUT 1 CONDITIONER

CHANNEL Ø & 1 MEASUREMENT CONTROL

COUNTER 1

J57

INPUT Ø
THRESHOLD Ø
INPUT 1
THRESHOLD 1
RETURN

IN Ø SYNC
IN 1 SYNC

DEBOUNCER CLK
SYNC CLK

FIXED REF
VARIABLE REF } SEE SHT 5

+5V
+14V
-15V

C19-C37, C39 .22
C40, C41, C42 .22

OFØ
AØ
A1
DBØ
DB1
DB2
DB3
DB4
DB5
DB6
DB7

RDCMOS(L)
WRCMOS(L)
RØX(L)
EVENØ1(L)
ENABLEØ1
STOPØ1(L)
RUNNINGØ1(H)
STARTØ1(L)
FUNCTIONØ1
Ø=COUNT
1=FREQ

OF1
FREQ REF
SYNC CLK
DEBOUNCER CLK

REF DES	1	2	+5VREM	+5V	+14V	-15V
U1	8		16			
U2	4,5,8		1			
U3	7		14			
U4			8			
U5				8		
U6						
U7						
U8						
U9						
U10						
U11						
U12						
U13						
U14						
U15		7		14		
U16		8		16		
U17		12		24		
U18		8		16		
U19		7		14		
U20		7		14		
U21		7		14		
U22		7		14		
U23		8		16		
U24		7		14		
U25		7		14		

REF DES	1	2	+5VREM	+5V	+14V	-15V
U26	8			16		
U27	7,8			16		
U28	20			26,40		
U29	3			1		
U30	8			16		
U31	7			14		
U32	7,8			16		
U33	7,8			16		
U34	7,8			16		
U35	7			14		
U36	8			16		
U37	7			14		
U38	7			14		
U39	8			16		
U40	8			16		
U41	8			16		
U42	7			14		
U43	12			24		
U44	8			16		
U45	7			14		
U46	8			1	16	
U47	8			16		
U48	8			16		
U49	12			24		
U50	8			16		

REF DES	1	2	4	+5V	+14V	-15V
U51	7			14		
U52	7			14		
U53	8			16		
U54	7,8			16		
U55	8			16		
U56	10			20		
U57	12			24		
U58						
U59	8			16		
U60						
U61						
U62						8	4
U63						8	4
U64						8	4
Z1-7						
XZ8						1,8	

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN MICROFARADS.

2. ALL RESISTORS ARE 1/4 W 5%.

3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

4. ⟩ LAYOUT PROVISIONS HAVE BEEN MADE FOR REPLACEMENT OF U2 (SHEET 4, ZONE D2) WITH THE COMPONENTS SHOWN IN DETAIL A (SHEET 5, ZONE D2). REFER TO THE SOLE SOURCE PLAN FOR U2 (JF/PN 586081).

5. ⟩ RESISTOR Z8 IS INSTALLED IN A SOCKET. THIS PART CAN BE REMOVED.

2280B-1067
(Sheet 1 of 5)

Figure 167-11. Counter/Totalizer Assembly Schematic Diagram
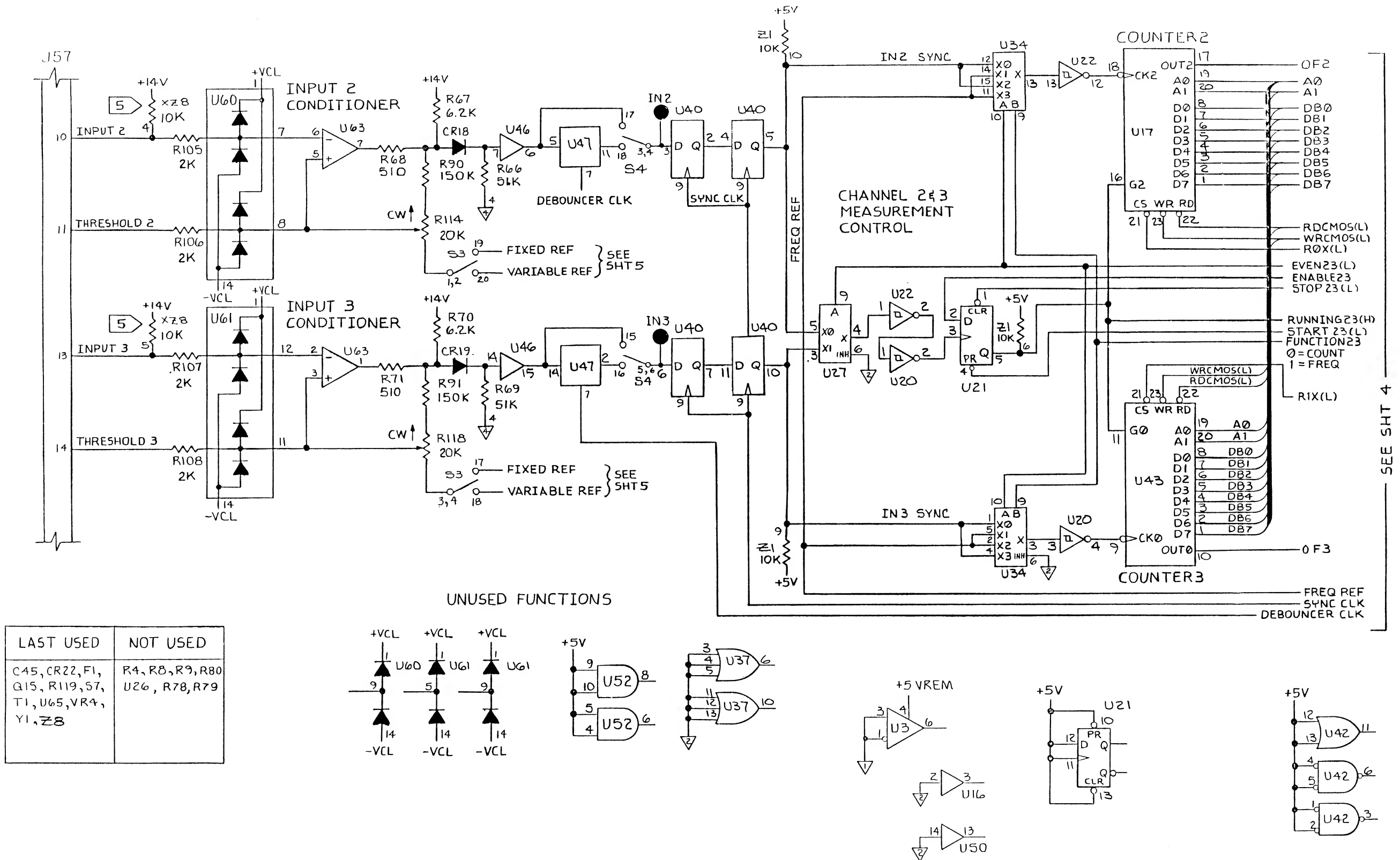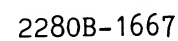
2280B-1667

2280B-1067
(Sheet 2 of 5)
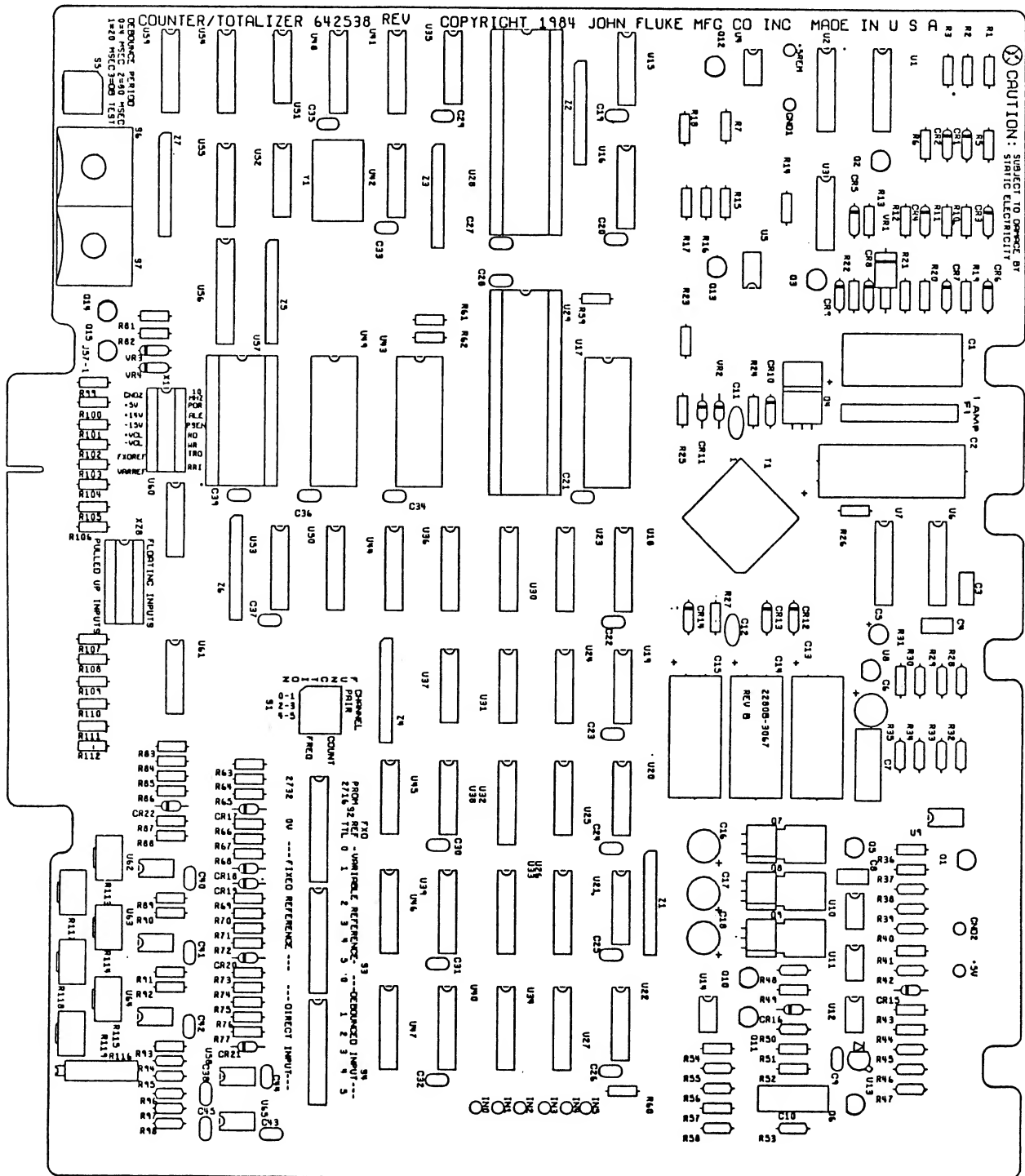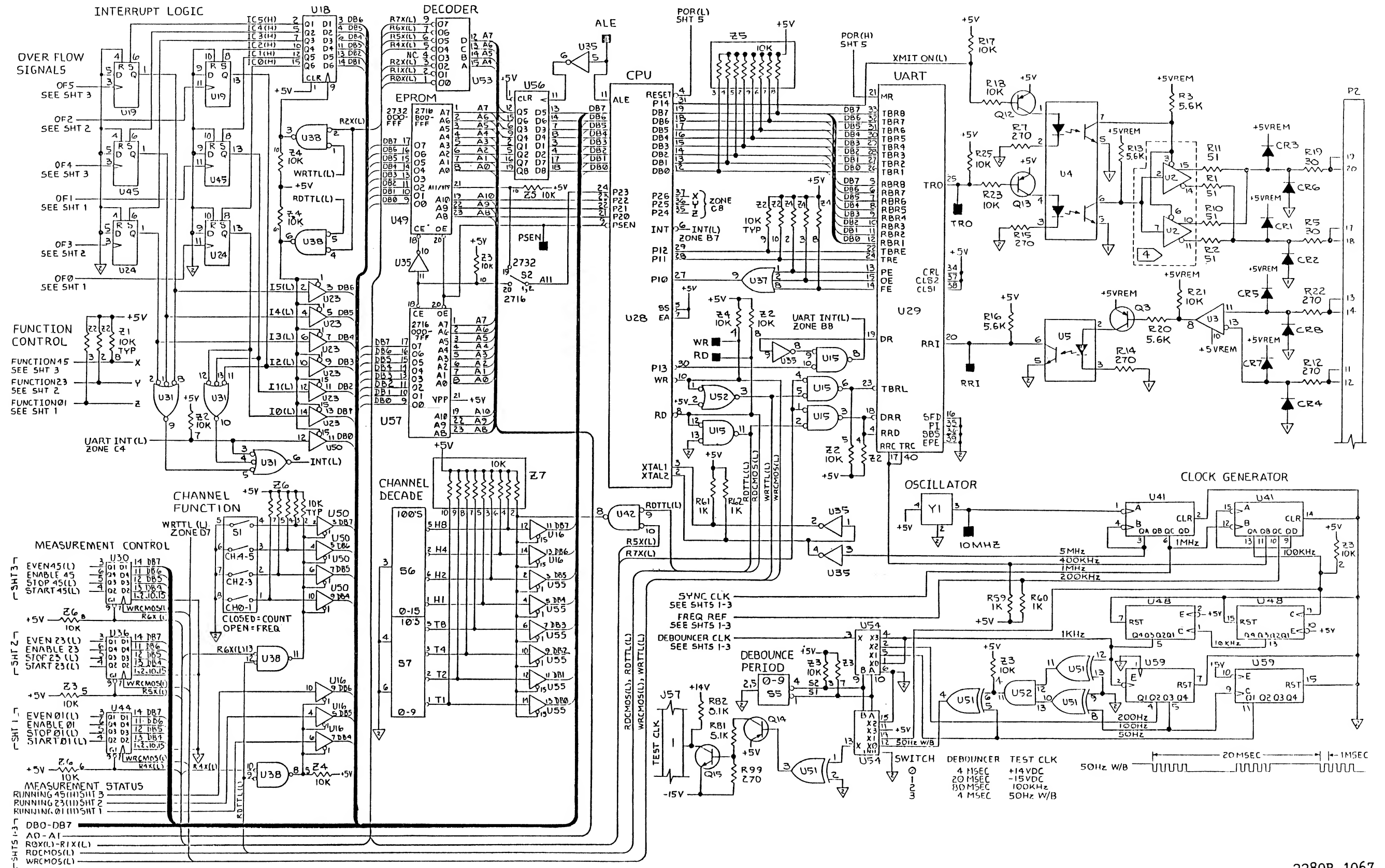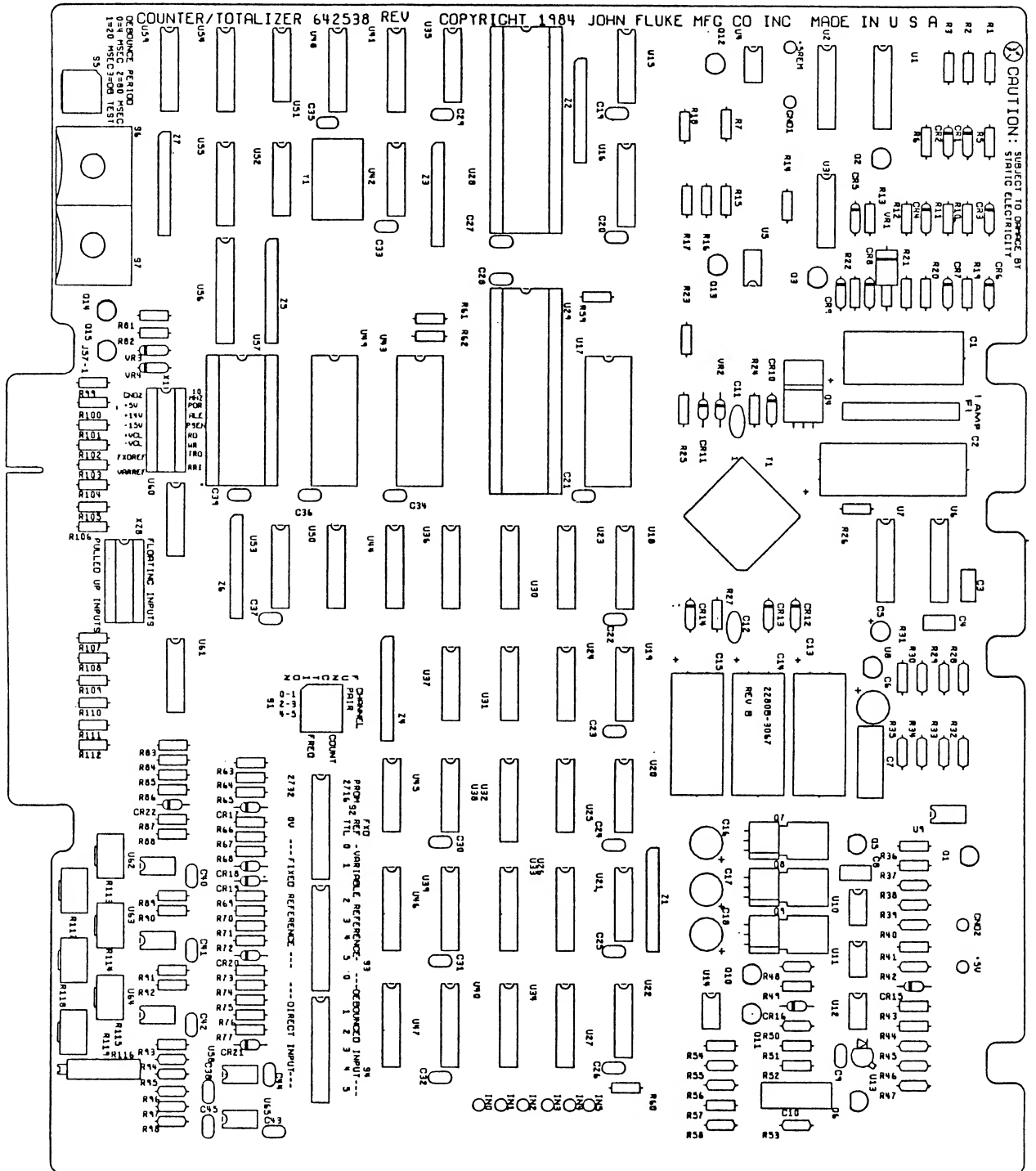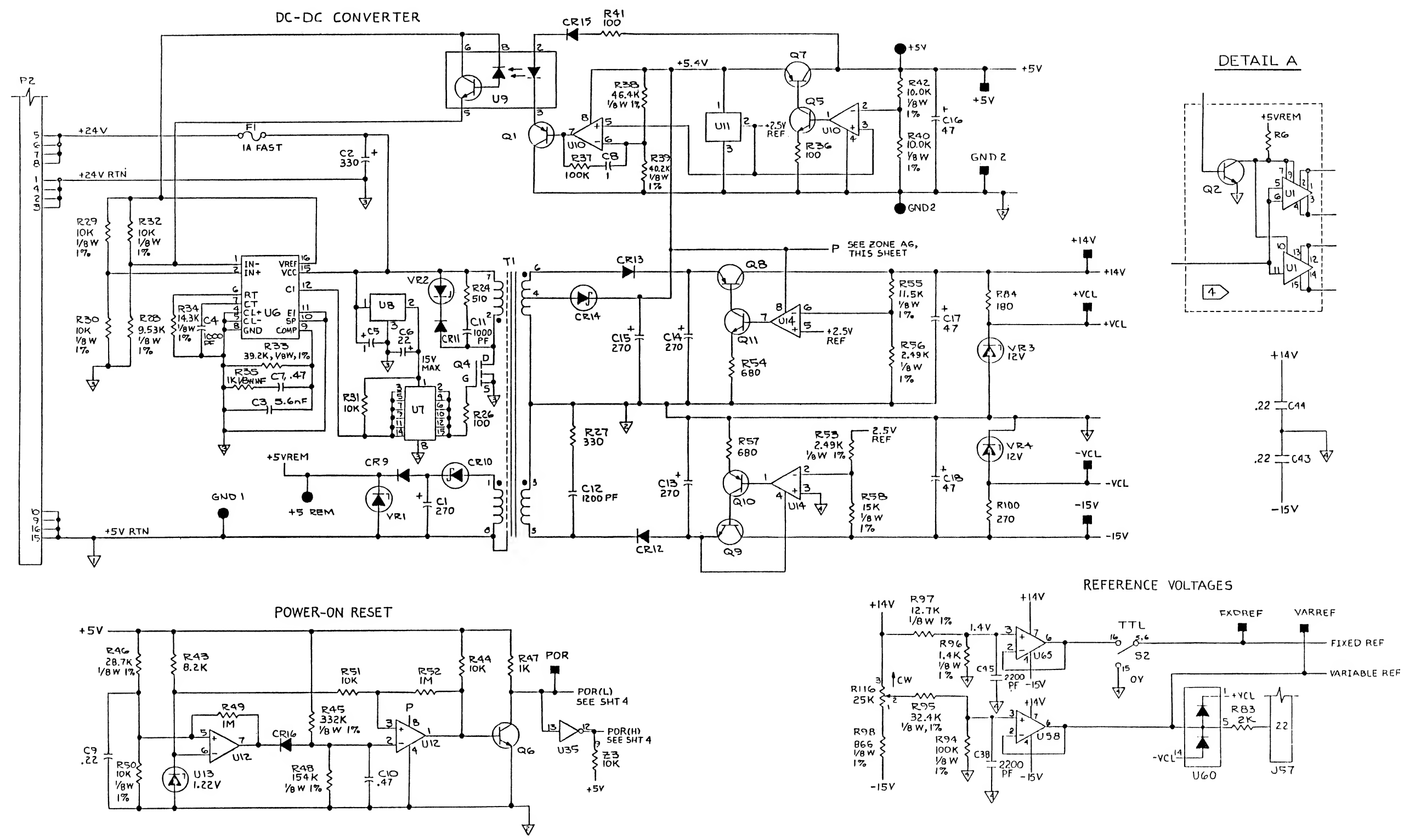
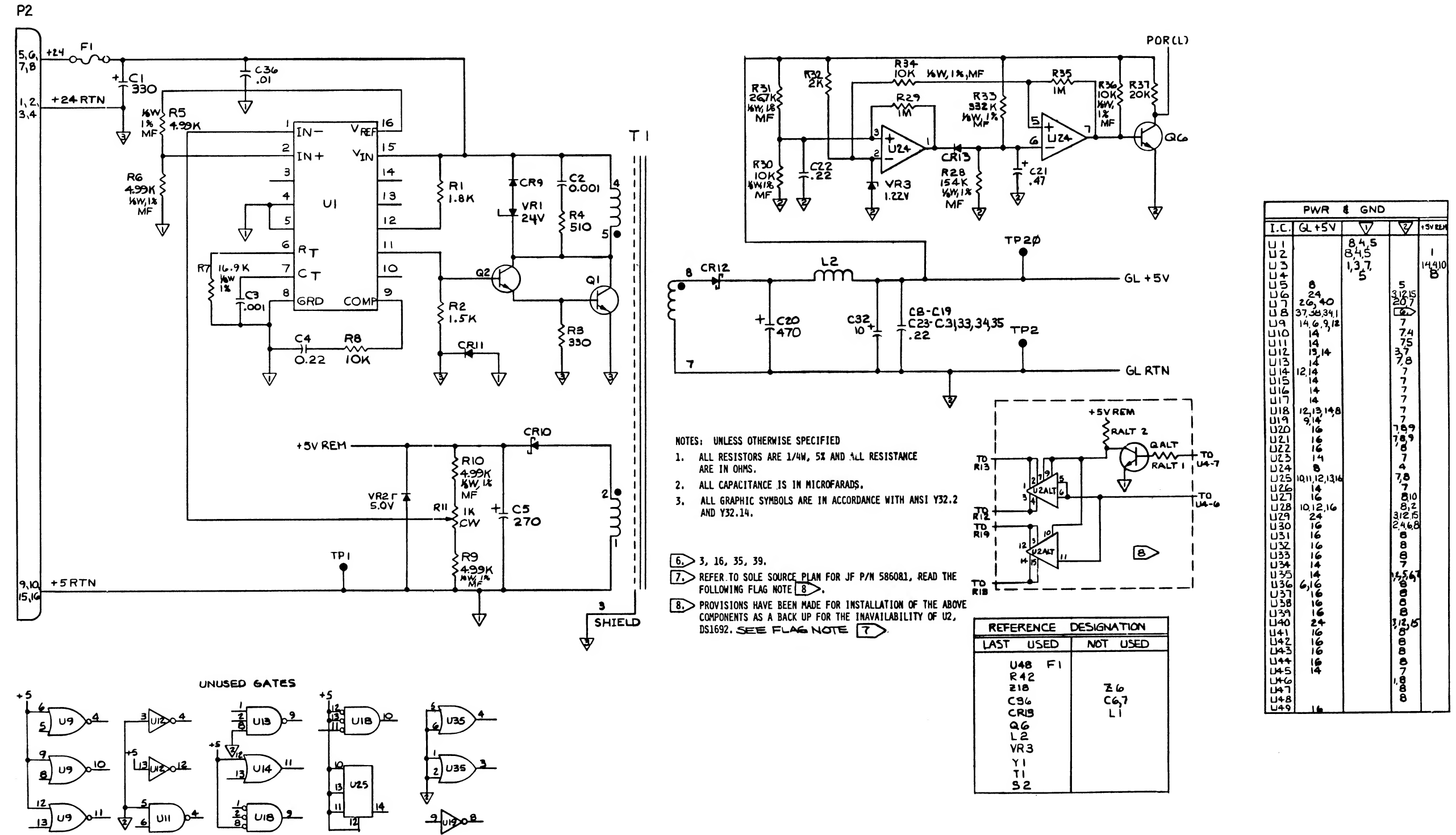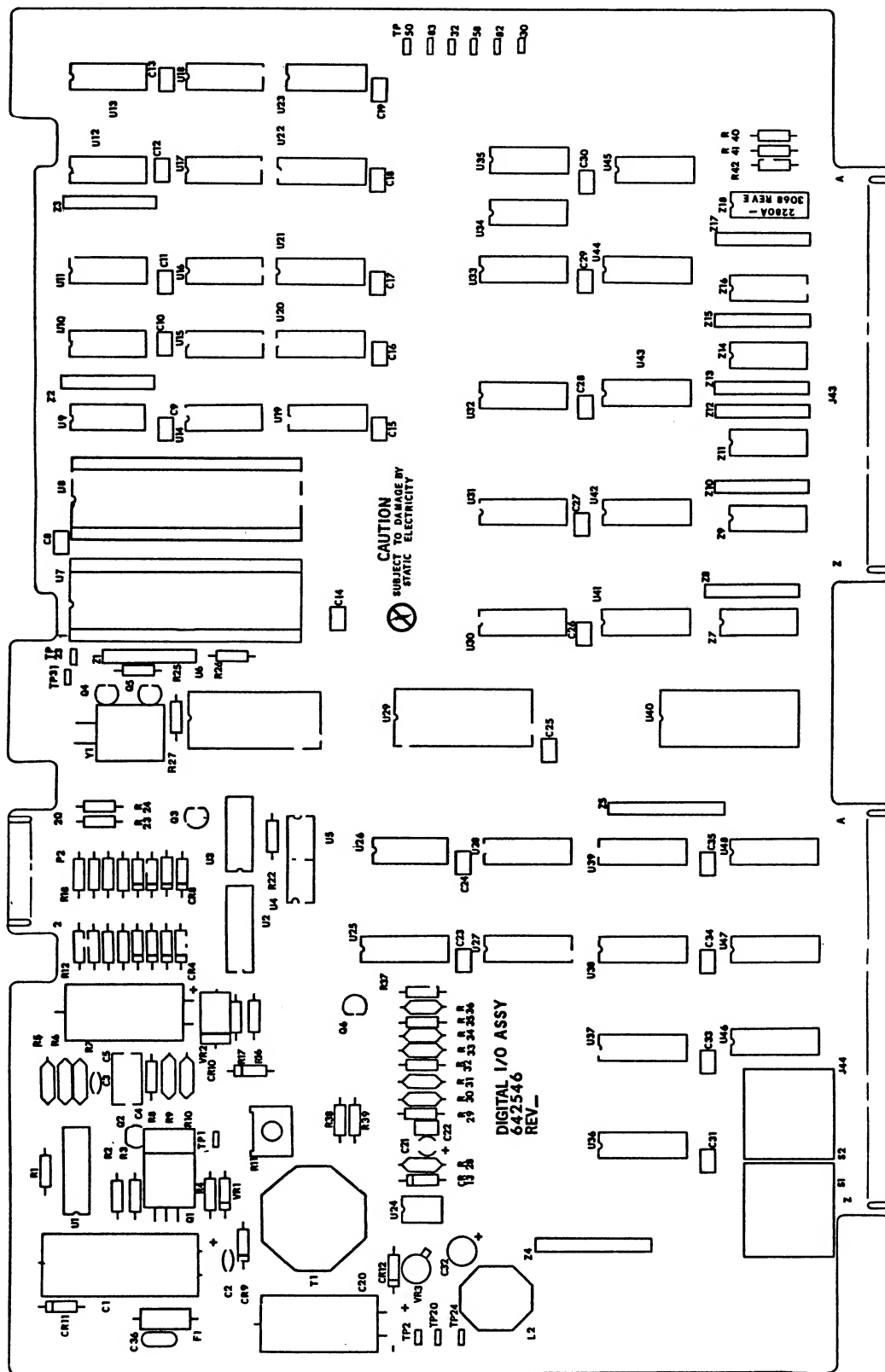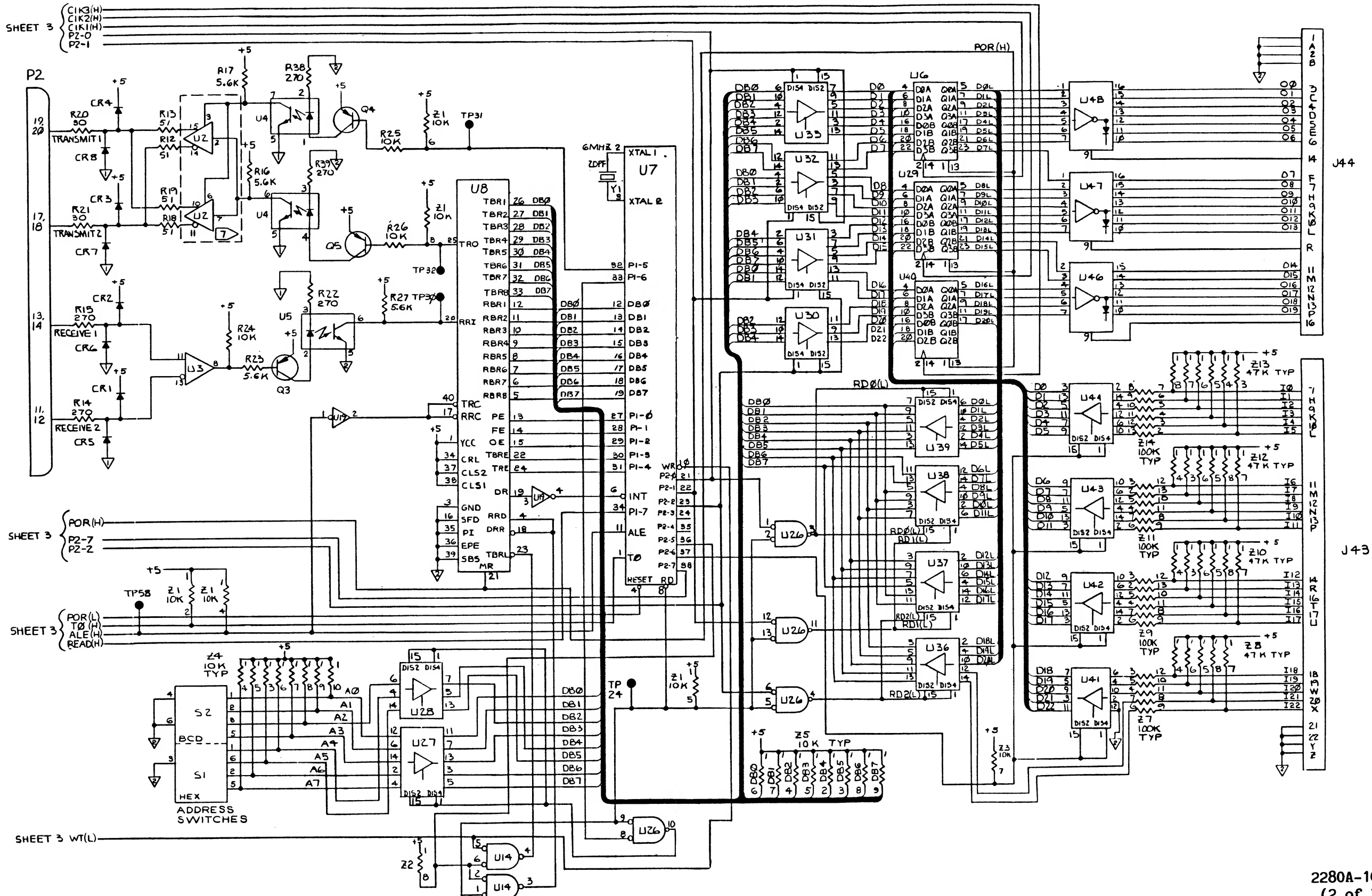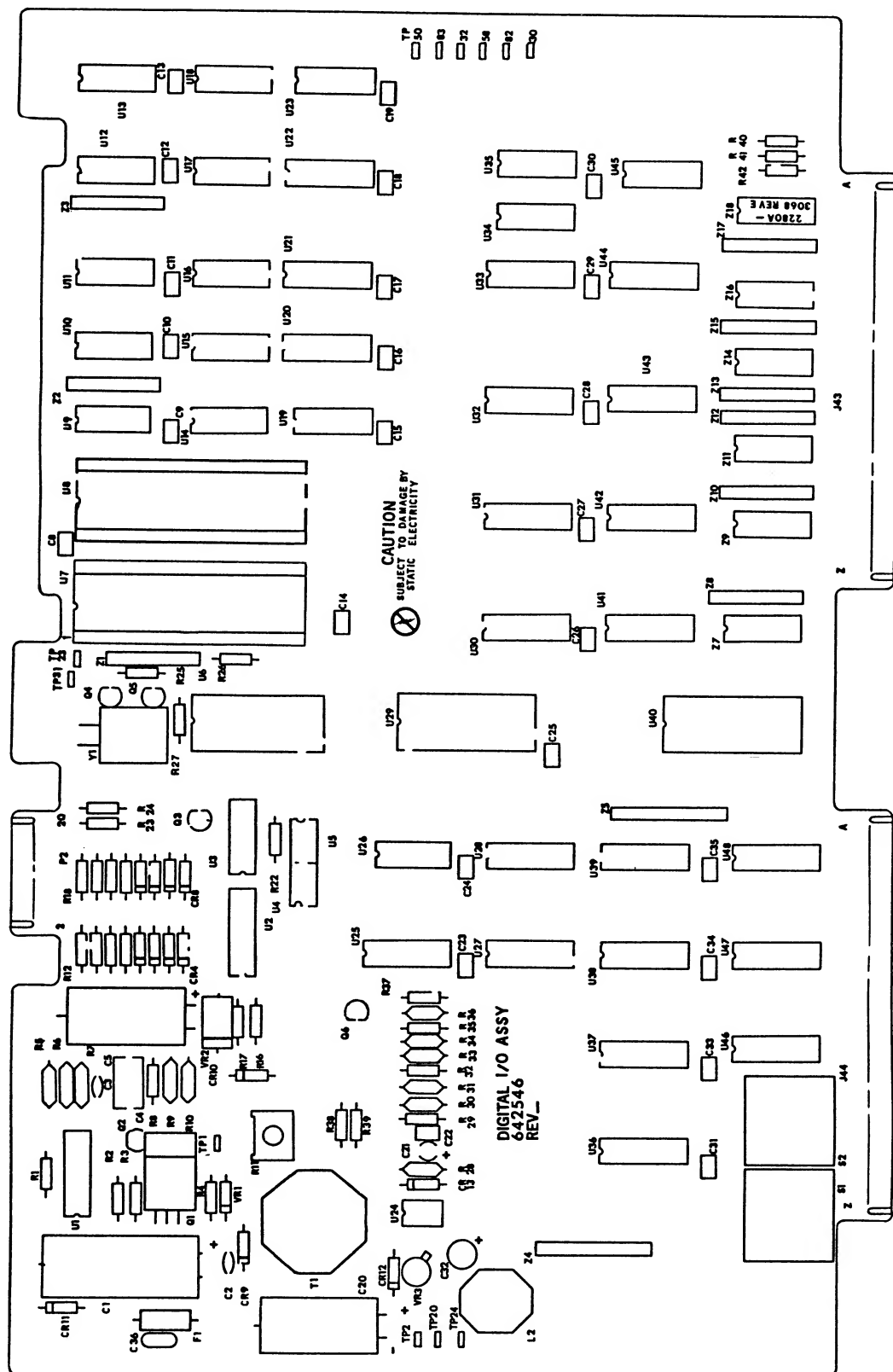**Figure 167-11. Counter/Totalizer Assembly Schematic Diagram (cont)**

167-F2

CAUTION: SUBJECT TO DAMAGE BY STATIC ELECTRICITY

COUNTER/TOTALIZER 642538 REV   COPYRIGHT 1984 JOHN FLUKE MFG CO INC   MADE IN U S A

DEBOUNCE   0R100
0=4 MSEC   2=80 MSEC
120 MSEC   3=0B TEST

FLOATING INPUTS

PULLED UP INPUTS

2732   0V   FIXED REFERENCE   DIRECT INPUT

PROM 92 REF   VARIABLE REFERENCE   DEBOUNCED INPUT
2716 TTL 0 1   1 2 3 4 5 0   0 1 2 3 4 5

CHANNEL
FREQ
COUNT

1 AMP   C2
F1

2280B-3067
REV B

2280B-1667

Figure 167-11. Counter/Totalizer Assembly Schematic Diagram (cont)

2280B-1067
(Sheet 3 of 5)

167-F3

COUNTER/TOTALIZER 642538 REV   COPYRIGHT 1984 JOHN FLUKE MFG CO INC   MADE IN U S A

CAUTION: SUBJECT TO DAMAGE BY STATIC ELECTRICITY

DEBOUNCE PERIOD
0=N MSEC 2=40 MSEC
1=20 MSEC 3=80 TEST

2280B-30667 REV B

1 AMP

FLOATING INPUTS
PULLED UP INPUTS

CHANNEL PAIR
FUNCTION
COUNT FREQ

PROM 32 REF
2716 TTL 0 1

FXO REF -VARIABLE REFERENCE-
--- FIXED REFERENCE --- ----DIRECT INPUT----
----DEBOUNCED INPUT----

2280B-1667

2280B-1067
(Sheet 4 of 5)

Figure 167-11. Counter/Totalizer Assembly Schematic Diagram (cont)

COUNTER/TOTALIZER 642538 REV COPYRIGHT 1984 JOHN FLUKE MFG CO INC MADE IN U S A

CAUTION: SUBJECT TO DAMAGE BY STATIC ELECTRICITY

2280B-1667

Figure 167-11. Counter/Totalizer Assembly Schematic Diagram (cont)

2280B-1067
(Sheet 5 of 5)

167-F5

CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY

DIGITAL I/O ASSY
642546
REV _

2280A - 3068 REV E

2280A-1668

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 1/4W, 5% AND ALL RESISTANCE IS IN OHMS.

2. ALL CAPACITANCE IS IN MICROFARADS.

3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

6. 3, 16, 35, 39.

7. REFER TO SOLE SOURCE PLAN FOR JF P/N 586081, READ THE FOLLOWING FLAG NOTE 8.

8. PROVISIONS HAVE BEEN MADE FOR INSTALLATION OF THE ABOVE COMPONENTS AS A BACK UP FOR THE INAVAILABILITY OF U2, DS1692. SEE FLAG NOTE 7.

UNUSED GATES

REFERENCE DESIGNATION

LAST USED	NOT USED
U48 F1	
R42	
Z18	Z6
C96	C6,7
CR18	L1
Q6	
L2	
VR3	
Y1	
T1	
S2	

PWR & GND

I.C.	GL +5V	▽	+5V REF
U1			1
U2		8,4,5	
U3		8,4,5	
U4		1,3,7,	
U5		5	
U6	8		5
U7	2,6,40	3,12,15	20,7
U8	37,38,39,1		26
U9	14,6,9,12		7
U10			7,4
U11	14		7,5
U12	15,14		3,7
U13	14		7,8
U14			7
U15	12,14		7
U16	14		7
U17	14		7
U18	12,13,14,8		7
U19	9,14		7,8,9
U20			7,8,9
U21	16		7,8
U22	16		7,8
U23	14		7
U24	8		4
U25	10,11,12,13,14		7,8
U26	16		7
U27	16		8,10
U28	10,12,16		8,2
U29	24		3,12,15
U30	16		2,4,6,8
U31	16		8
U32	16		8
U33	16		8
U34	14		7
U35	6,16		14,5,6,7
U36	6,16		8
U37	16		8
U38	16		8
U39	16		8
U40	24		3,12,15
U41	16		8
U42	16		8
U43	16		8
U44	16		8
U45	14		7
U46			8
U47			8
U48			8
U49	16		8

CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY

DIGITAL I/O ASSY
642546
REV__

2280A-1668

Figure 168-7. Digital I/O Assembly Schematic Diagram (cont)

2280A-1068
(2 of 3)

CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY

DIGITAL I/O ASSY
642546
REV_

2280A-3068 REV E

2280A-1668

Figure 168-7. Digital I/O Assembly Schematic Diagram (cont)

TB 4

TB2

TB7

TB6

TB5

TB3

TB1

P44

22
z

P44

Figure 169-2. Status Output Connector Schematic Diagram

2280A-1069

669

2280B-1670

Figure 170-11. Analog Output Schematic Diagram

2280B-1070
(1 of 4)

170-F1

2280B-1670

Figure 170-11. Analog Output Schematic Diagram (cont)

2280B-1070
(2 of 4)

170-F2

2280B-1670

2280B-1070
(3 of 4)

Figure 170-11. Analog Output Schematic Diagram (cont)

170-F3

2280B-1670

2280B-1070
(4 of 4)

Figure 170-11. Analog Output Schematic Diagram (cont)

170-F4

R19 R18 R17 R16 R15 R14 R13 R12 R11 R10

P36 R20

TB2

TB4

R9 R8 R7 R6 R5 R4 R3 R2 R1 R0

TB1

TB3

P37

2280A-1671

P37

P36

TB1
HIGH

TB2
HIGH

TB3
LOW

TB4
LOW

CHANNEL 0
CHANNEL 1
CHANNEL 2
CHANNEL 3
CHANNEL 4
CHANNEL 5
CHANNEL 6
CHANNEL 7
CHANNEL 8
CHANNEL 9

CHANNEL 10
CHANNEL 11
CHANNEL 12
CHANNEL 13
CHANNEL 14
CHANNEL 15
CHANNEL 16
CHANNEL 17
CHANNEL 18
CHANNEL 19

2280A-1071

Figure 171-2. Current Input Connector Schematic Diagram

P54

P55

JR1I

JR1V

JR2I

JR2V

JR3I

JR3V

JR4I

JR4V

JR5I

JR5V

TB1 TB2 TB3 TB4 TB5 TB6 TB7 TB8 TB9 TB10

2280A-1674

Figure 174-2. Transducer Excitation Connector Schematic Diagram
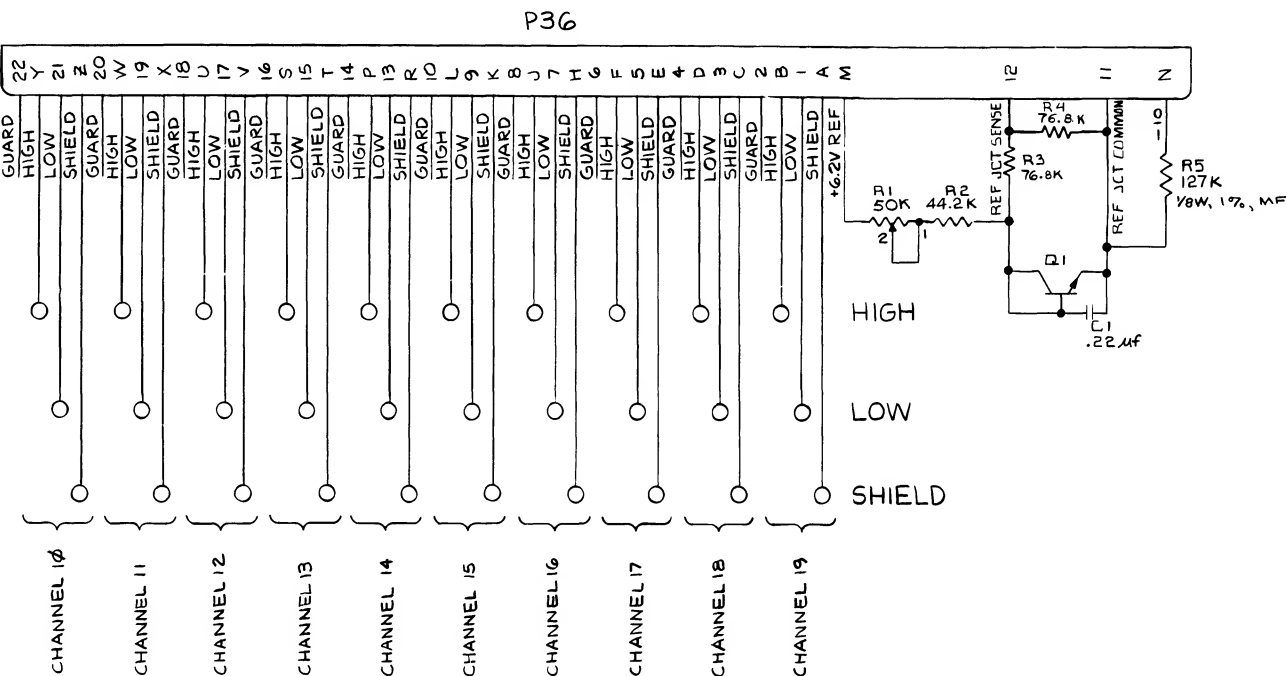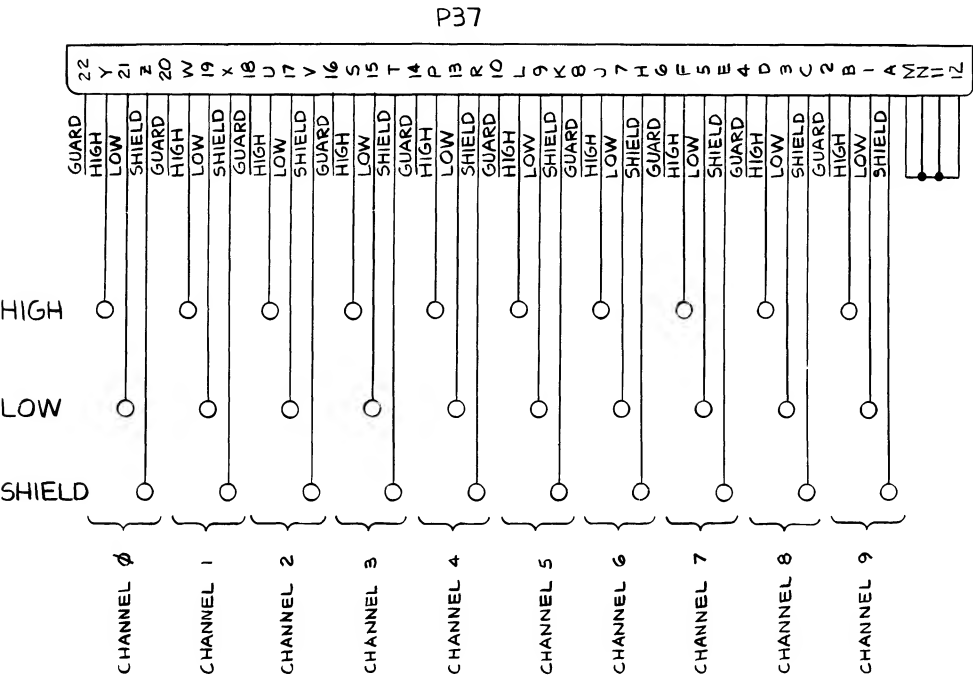
NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

2. JUMPERS ON JR1 – JR5 ARE SHOWN INSTALLED IN CURRENT CONFIGURATION.

2280A-1074

2280A-1675

P37

P36

HIGH

LOW

SHIELD

HIGH

LOW

SHIELD

CHANNEL Ø
CHANNEL 1
CHANNEL 2
CHANNEL 3
CHANNEL 4
CHANNEL 5
CHANNEL 6
CHANNEL 7
CHANNEL 8
CHANNEL 9

CHANNEL 10
CHANNEL 11
CHANNEL 12
CHANNEL 13
CHANNEL 14
CHANNEL 15
CHANNEL 16
CHANNEL 17
CHANNEL 18
CHANNEL 19

+6.2V REF
REF JCT SENSE
REF JCT COMMON

R1 50K
R2 44.2K
R3 76.8K
R4 76.8 K
R5 127K   1/8W, 1%, MF

Q1
C1 .22 μf

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCES ARE IN OHMS.
2. ALL RESISTORS ARE 1/8W, MF, .1%.
3. ALL CAPACITANCE IN MICROFARADS.
4. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

REF DES
LAST USED
Q1
C1
R5

2280A-1075

Figure 175-2. Isothermal Input Connector Schematic Diagram

P36

TB2

TB4

TB6

R1

TB1

TB3

TB5

P37

2280A-1676
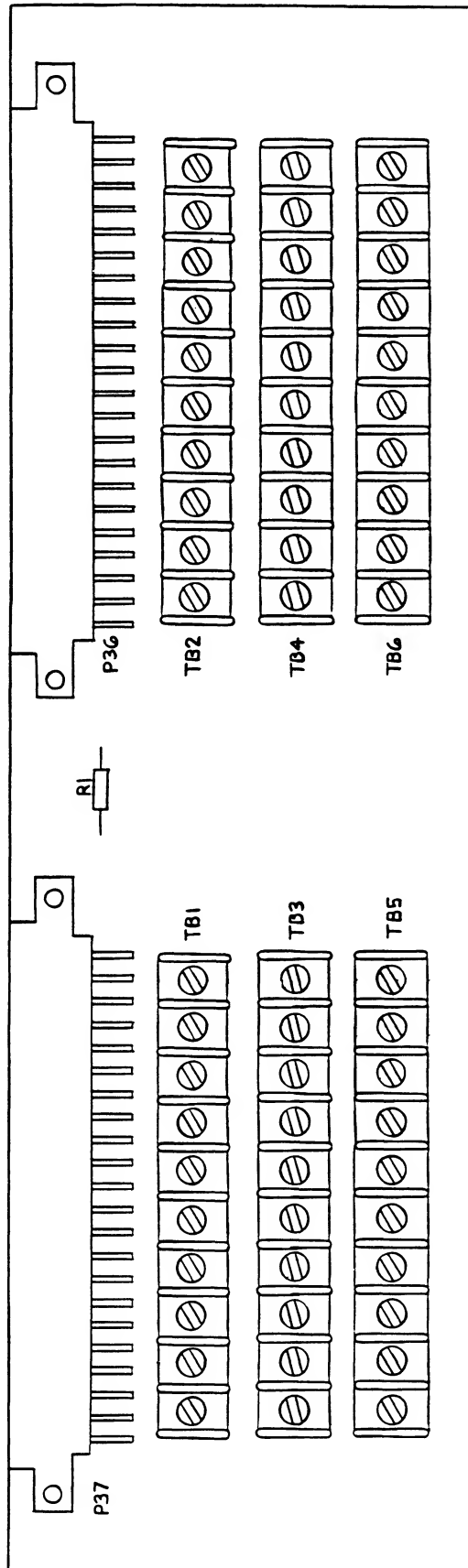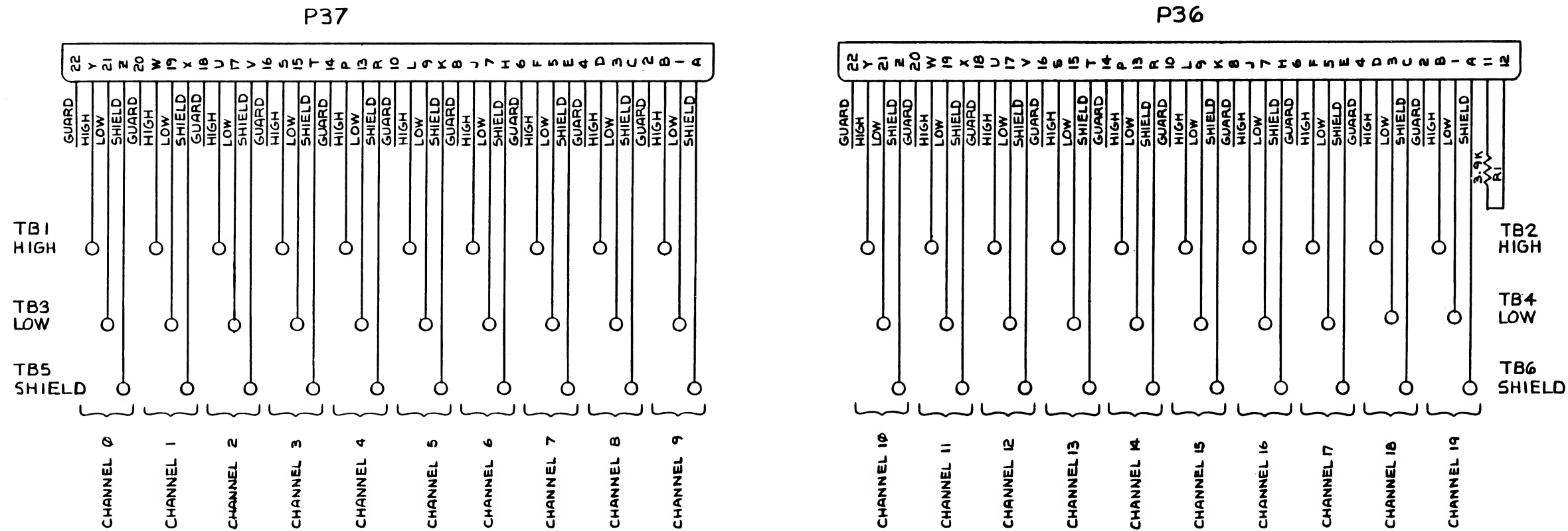
Figure 176-2. Voltage Input Connector Schematic Diagram

2280A-1076

176-F1

P39-1

A

HI EXC
HI
LO
LO EXC
LO COM

HI EXC
HI
LO
LO EXC
LO COM

CH18 CH19
CH16 CH17
CH14 CH15
CH12 CH13
CH10 CH11
CH8   CH9
CH6   CH7
CH4   CH5
CH2   CH3
CH0   CH1

NN : DO NOT CONNECT TO LO COM.
NNR : JUMPER HI TO HI EXC,
JUMPER LO EXC TO LO COM.
NNCM : JUMPER HI TO HI EXC,
DO NOT CONNECT TO LO COM.

-22
P40

HI EXC
HI
LO
LO EXC
LO COM

HI EXC
HI
LO
LO EXC
LO COM

2280B-1677
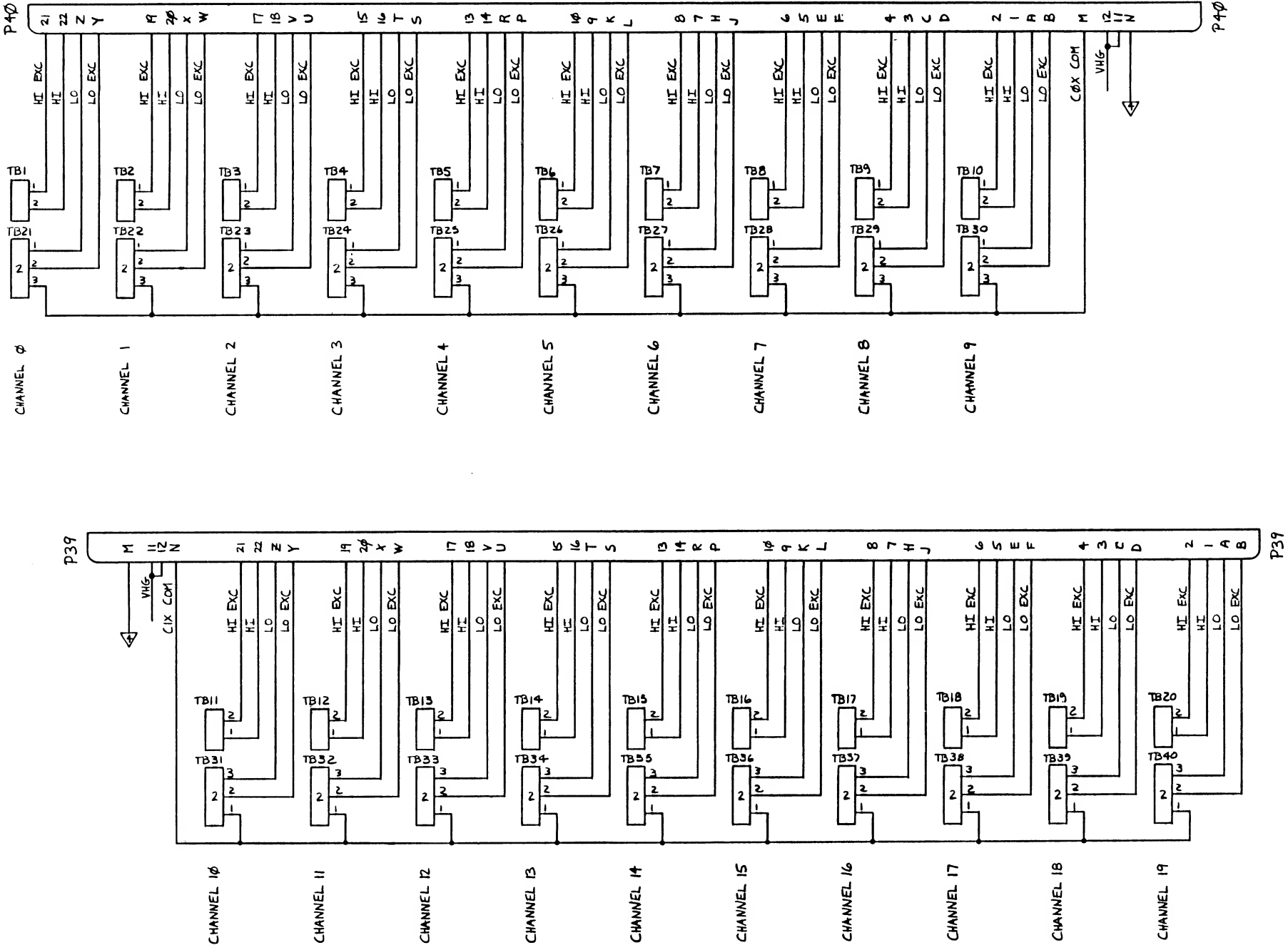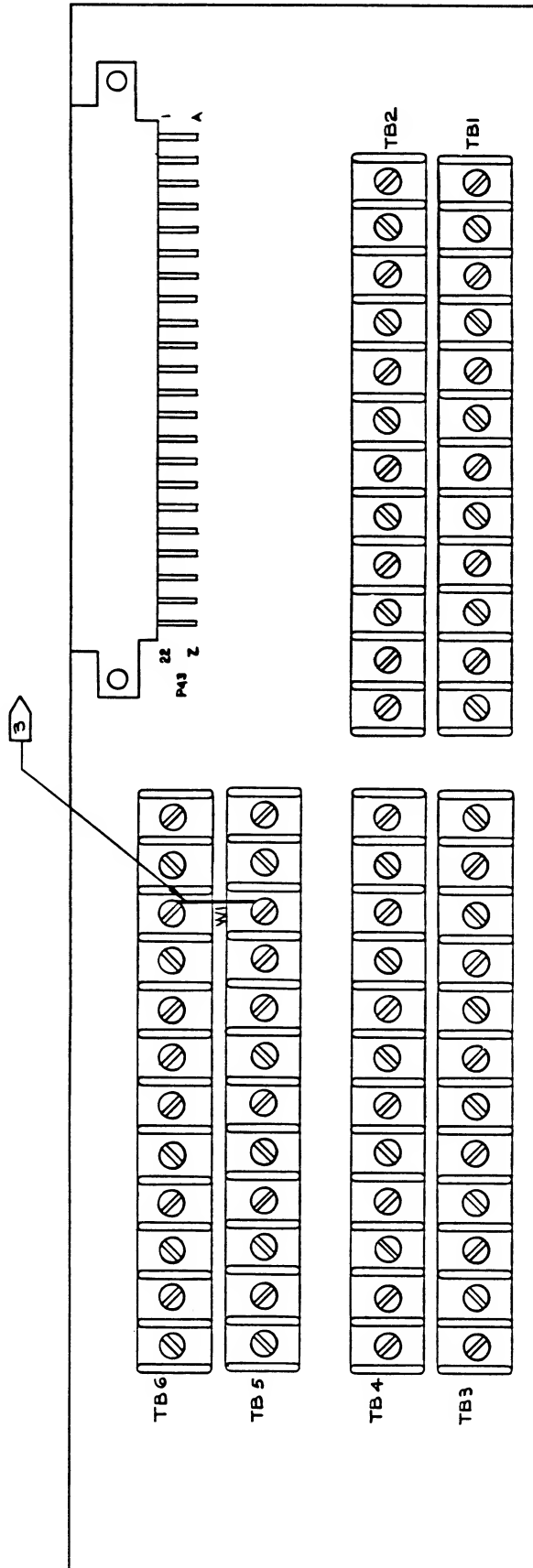
NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

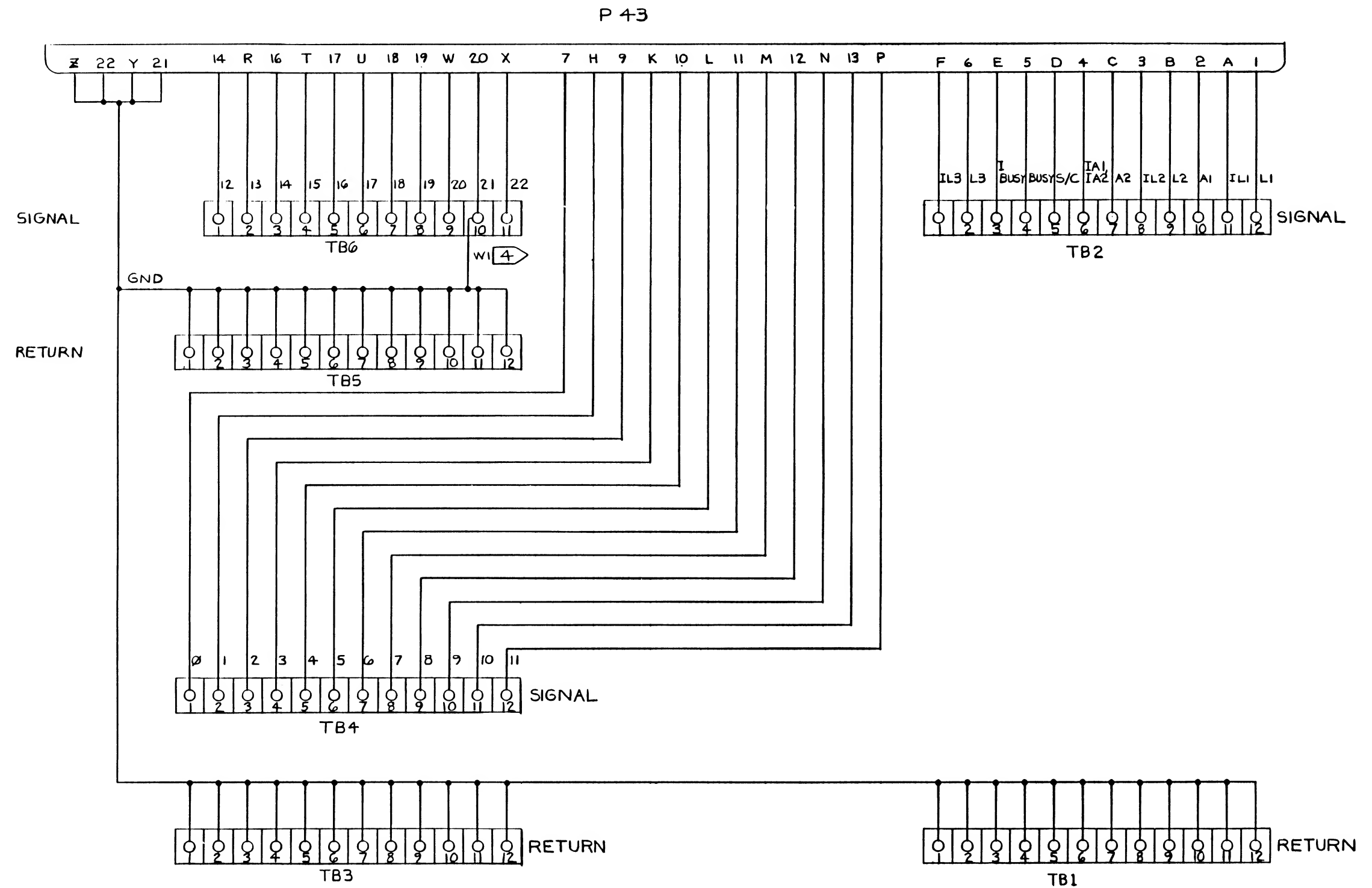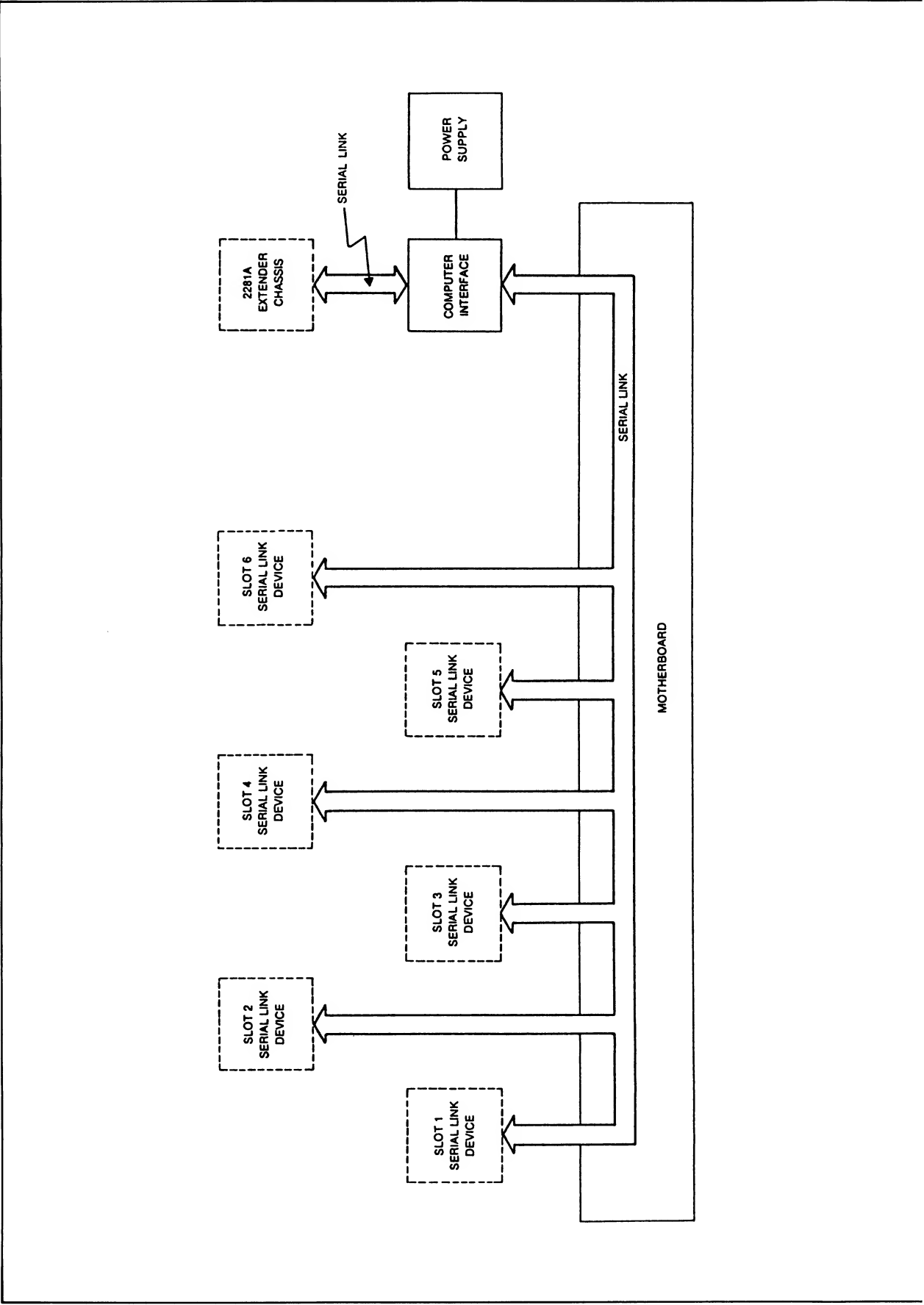Figure 177-2. RTD/Resistance Connector Schematic Diagram

TB2

TB1

P43 22 Z

3

W1

TB6

TB5

TB4

TB3

2280A-1679

Figure 179-2. Digital/Status Input Connector Schematic Diagram

2280A-1079

POWER SUPPLY

SERIAL LINK

2281A EXTENDER CHASSIS

COMPUTER INTERFACE

SLOT 6 SERIAL LINK DEVICE

SLOT 5 SERIAL LINK DEVICE

SLOT 4 SERIAL LINK DEVICE

SLOT 3 SERIAL LINK DEVICE

SLOT 2 SERIAL LINK DEVICE
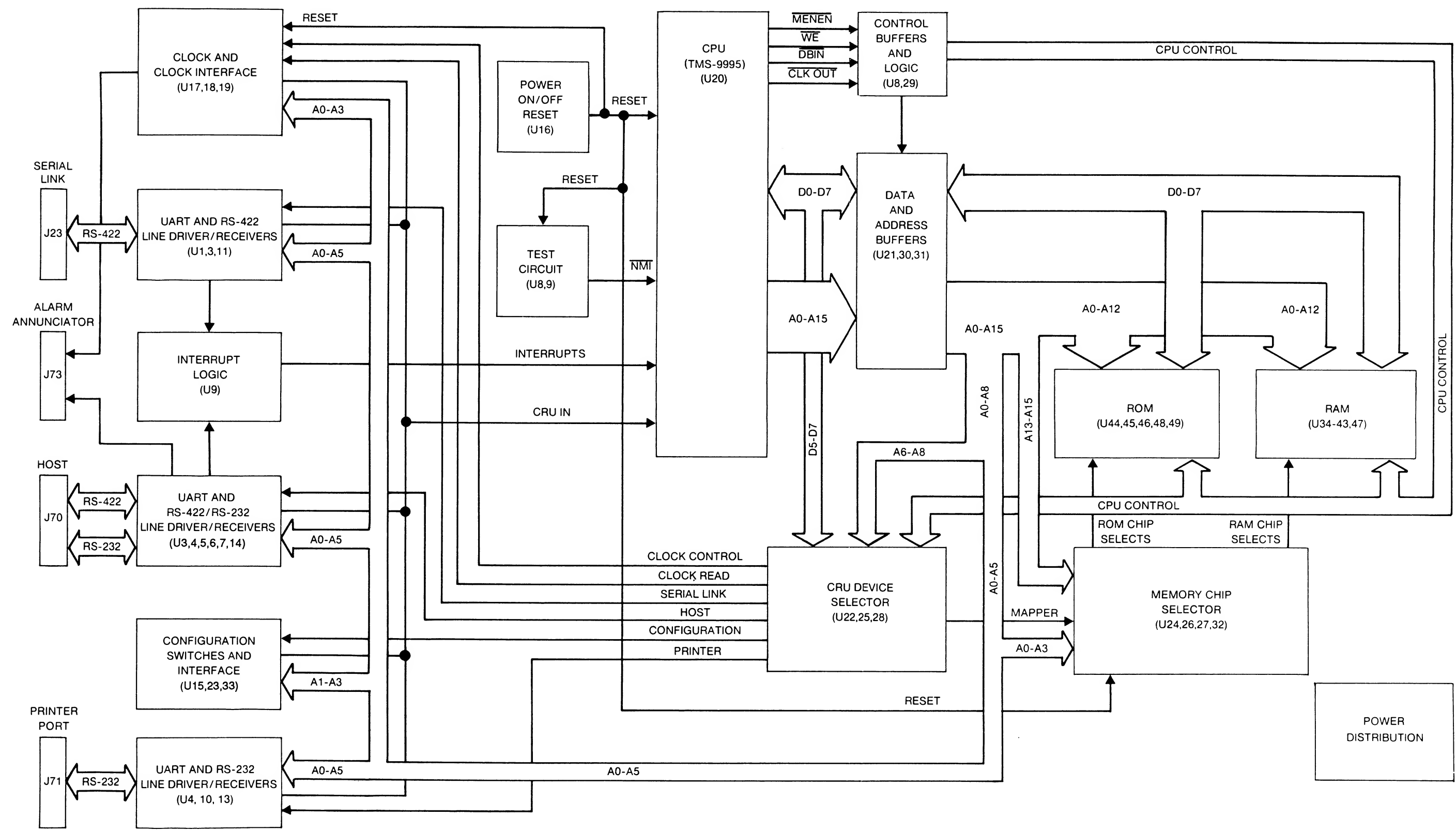
SLOT 1 SERIAL LINK DEVICE

SERIAL LINK

MOTHERBOARD

Figure 9A-1. Computer Interface Assembly (Scan/Alarm)
(Functional Block Diagram)